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THE UNIVERSITY OF ALBERTA

SYNECOLOGY OF A

FESTUCA SCABRELLA TORR. GRASSLAND

by

R.A. WROE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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ABSTRACT

A synecological study was conducted on a 65 hectare area of hilly rangeland in south-central Alberta. The purpose of the study was to characterize near-pristine vegetation and to investigate herbage production in the various plant communities. The results are discussed in relation to range management.

Eight plant communities were identified by species dominance and herbage production. These include one meadow-, two shrub-, one tree-, and four grassland-dominated communities. The plant groupings are presented below as they occurred along a wet to dry moisture gradient.

Stands of the meadow community, which were dominated by *Carex atherodes*, occurred at the bottom of dish-like depressions. Stands of this community covered 11.1 percent of the area. The average herbage yield was 5000 Kg./ha. in 1969 and very little in 1970. The range in production is considered to be attributable to the depth and duration of water in the meadow.

The shrub community, dominated by *Salix petiolaris*, occupied the moist areas on the perimeter of the depressions as well as other moist locations. The stands of this community covered 6.8 percent of the area and the boundaries appeared to have been relatively static. The herbage production was about 500 Kg./ha. in 1969.

The tree community, dominated by *Populus tremuloides* occupied the areas around the *Salix* community. The area occupied by stands of this community has increased from 0.2 percent in 1907 to 3.4 percent in 1966 in the vicinity of the study area. This community increased at the

expense of the surrounding grassland. Herbage production was about 500 Kg./ha.

The second shrub community was dominated by *Symphoricarpos occidentalis*. Stands of this community occurred as islands within the grassland and covered 8.3 percent of the area. A broad ecological amplitude of the dominate species was indicated by the unpredictability of stand locations. Although annual production was 2000 to 2500 Kg./ha., 45 percent of this was contributed by *Symphoricarpos*.

The grassland was made up of stands of *Festuca scabrella*, *Festuca-Stipa*, *Stipa-Artemisia* and *Koeleria-Agropyron* communities which occupied 50.9%, 11.0%, 2.3%, and 0.5% of the study area, respectively. The *Stipa-Festuca* dominated areas occupied the southern exposures of the hills. The *Stipa-Artemisia* community occupies the south exposure of the hilltops. The species composition of these stands was considered to be altered by grazing animals in the past. The *Koeleria-Agropyron* community occupied the solonetz soils occurring in small patches. The annual herbage production of the grassland areas varied from 1160 to 2230 Kg./ha.

Grazing animals, when offered a variety of plant communities, demonstrated a preference for the hilltop and south slope communities. The palatability of the plants dominating the communities or the tendency of grazing animals to overutilize poor range sites before moving to other plant communities may be the cause. The preference demonstrated by grazing animals creates a range utilization problem in the management of these areas. To gain efficient range use, one will have to consider sacrificing the preferred areas, experimenting with

grazing rotations, changing the grazing season, mowing or fertilizing underutilized areas to promote uniform utilization.

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INTRODUCTION

Rough fescue *(Festuca scabrella)*[1] occurs in the prairie areas of southwestern Alberta and the Cypress Hills as well as in the aspen parkland of Alberta, Saskatchewan, and Manitoba. The aspen parkland is a major vegetation zone where groves of *Populus tremuloides* are interspersed with prairie. The parkland zone is a tension area between the prairie to the south and east, and the boreal forest to the north. Within the borders of the parkland there is competition between the aspen groves and the grassland. The fescue grassland occupies the black and northern part of the dark brown soil zones of western Canada. The parkland is a mosaic of plant communities and is frequently associated with rough topography. The depressions support sedge *(Carex spp.)* meadows having a fringe of willow *(Salix spp.)*. Outside the willow fringe varying amounts of aspen *(Populus tremuloides)* occur. The grasslands vary from western porcupine grass *(Stipa spartea* var. *curtiseta)* dominated grassland on the southern slopes, to a rough fescue *(Festuca scabrella)* dominated grassland on the remainder. Areas of western snowberry *(Symphoricarpos occidentalis)* dominated communities occur throughout the grasslands. These vegetational types show a wide variation in estimated forage production.

The prairie vegetation, occurring within the parklands, has been regionally described under the fescue and mixed prairie associations of western Canada. Recently the ecology of sedge communities has been described (Walker and Coupland 1968). The aspen and willow communities within the parkland zone have been largely ignored.

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[1] Vascular plant nomenclature follows Moss (1959).

Range management studies have been lacking in the parkland areas. In Alberta, they have been mainly confined to the mixed prairie in southeastern Alberta and the fescue prairie of southwestern Alberta. These studies have been conducted on relatively uniform vegetational areas. Grazing animals when subjected to a choice of range types[1], as available in parkland range, are selective. Evidence of this is common on parkland ranges, as demonstrated by poor and excellent range condition[2] occurring side by side in the same pasture. This is observed when range condition is considered. Vegetation on the south facing slopes deteriorates first and the last vegetation to be affected is that on the north slopes.

Yankowsky (1970), in his outlook for Canadian beef, concluded that the total demand for beef is projected to increase 62 percent between 1967-1969 and 1980. Love (1968) indicated that cattle numbers will have to increase more than 50 percent in Alberta by 1980. The need to support more grazing animals in Alberta will require more intensive management of native ranges.

In view of the predicted increase in cattle numbers and the lack of information about the rangelands a study area was selected in the parkland zone of the province. Range ecology information is required to intensively manage areas of native vegetation. Since similar vegetation types occur over large areas of the aspen parkland, results of the study can probably be safely applied to these rangelands.

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[1] Range type is used synonymously with plant community.

[2] Range condition is the state and health of the range based on what the range is naturally capable of producing.

The objectives of this study were:

i) to characterize pristine or near-pristine vegetation on an area in the parkland portion of Alberta.

ii) to determine the annual herbage production of the plant communities.

iii) to apply the results to range management in the surrounding area.

The legal land description of the study area was the north-west quarter of section fourteen, township thirty-four, range nineteen, west of the fourth meridian.

DESCRIPTION OF THE AREA

1. Climate

The climate in the study area is generally described as a continental type, having cold winters and short, cool summers. Sanderson (1948) places this area within the sub-humid moisture region of western Canada. This area is on the northern edge of the main chinook belt and is somewhat influenced by these winds. A chinook is a mass of dry, warm air from the west which causes rapid changes in temperature.

A general summary of the climate as given by Chapman and Brown (1966) is presented in Table 1.

Table 1. Summary of regional climate

July mean temperature	17 to 18 C
January mean temperature	-13 to -12 C
Mean frost free days	100 to 110
May to September precipitation	23 to 25 cm.
Average total precipitation	36 to 41 cm.
Potential evapo-transpiration	51 to 56 cm.
Average annual water deficiency	10 to 15 cm.

The July mean temperature is between 17 and 18° C compared to 20° C in the mixed prairie at Manyberries and 14° C in the fescue prairie of the Porcupine Hills.

The January mean temperature is about the same as the mixed prairie but 3° C warmer than the fescue prairie of the Porcupine Hills. The frost free period is about the same as the mixed prairie but longer by 30-40 days than the fescue prairie of southwestern Alberta. The May to September precipitation and the total precipitation falls between that of the mixed prairie and fescue prairie in Alberta.

Precipitation during the study is best described by comparing long term averages (1931 - 1960) to the years 1968, 1969 and 1970. The nearest meteological stations having long term averages were Three Hills and Trochu located to the southwest, 58 and 34 kilometers, respectively, from the study area. Precipitation figures are given in Table 2.

Table 2. Annual precipitation (cm.) for Trochu and Three Hills

	Three Hills				Trochu			
Month	1968	1969	1970	Average 1931-60	1968	1969	1970	Average 1931-60
Jan.	0.96	1.35	1.24	1.24	1.52	2.01	1.57	2.06
Feb.	0.71	1.88	1.19	1.47	0.83	2.67	0.76	1.96
Mar.	1.22	0.99	2.24	1.78	1.35	0.94	1.83	2.39
Apr.	2.59	1.27	3.48	2.62	1.57	1.02	2.92	3.41
May	3.73	1.09	3.51	4.39	1.35	1.85	4.19	3.91
June	8.38	3.96	17.65	7.72	6.60	4.24	15.70	6.30
July	11.58	5.23	3.07	5.51	11.65	7.13	5.77	5.38
Aug.	3.51	3.96	0.43	6.10	4.14	4.70	0.76	8.58
Sept.	8.46	7.57	1.62	3.23	4.83	10.26	2.77	2.16
Oct.	1.55	2.41		2.36	2.18	3.30		1.98
Nov.	0.58	0.76		1.35	0.81	0.58		1.24
Dec.	3.56	0.86		1.14	3.35	1.73		1.90
Total	46.83	31.33		38.91	40.18	40.43		41.26

Smoliak (1956) found that range forage production was highly correlated to May and June precipitation. Rogler and Haas (1947) report a highly significant relationship between soil moisture the preceding fall and herbage yield. The higher the May and June precipitation the higher the range production. The higher the soil moisture the preceding fall the better the yield would be. With this in mind, precipitation figures in Table 2 gave indications of growing conditions during the study. The long term average for May and June precipitation

amounted to 10.21 cm. at Trochu and 12.11 cm. at Three Hills. During 1969 the May and June precipitation was 6.09 and 5.05 cm. respectively. The 50 percent reduction from the average would indicate less than average yield. The situation changed in 1970 when May and June precipitation amounted to 19.89 and 21.16 cm. This was approximately twice the normal and indicated better than average growing conditions. Precipitation from August through October was higher than average during the preceding fall of both 1969 and 1970, with no real differences between stations. The favorable moisture conditions in the autumns of 1968 and 1969 may compensate for the great differences in May and June precipitation between 1969 and 1970.

2. History and Land Use

Prior to the arrival of white man (*Homo sapiens sapiens* Linnaeus), the parkland region was populated with large herbivores such as bison (*Bison bison bison* Linnaeus), wapiti or elk (*Cervus canadensis nelsoni* Bailey), prong-horned antelope (*Antilocapra americana americana* Ord), mule deer (*Odocoileus hemionus hemionus* Rafinesque), and a few white tailed deer (*Odocoileus virginianus dacotensis* Goldman and Kellogg). Reports of early explorers, as reported by Bird (1961), indicated that of these ungulates the bison had the dominant influence on the vegetation. Fire started by nomadic Indians (*Homo sapiens americanus* Linnaeus) and by lightning was also of significant importance. Bird (1961) indicated that bison overgrazed areas of the prairie, rubbing and trampling groves of trees and destroying them. These impressions appear to originate from one account in the journals of Alexander Henry, during the period 1799 to 1814, in describing the country west of the

Red River. The Indian's influence on vegetation appeared to be mainly through fires used as a mode of telegraphic communications; or to modify movement of bison, their chief source of food.

Roe (1951) indicated that bison sought groves of trees for shade and rubbing. However, it was improbable that bison could have had a significant influence on the reduction of trees in the parkland area. Fire was the more probable answer to deforestation. Roe (1951) suggested that bison were rather nomadic and roving. He stated that one of the known wintering areas for bison was the Beaver Hills, in which the study area is located. Bison were generally absent in this area in the summer. During the summer large numbers were reported in the mixed prairie region to the south.

There was conflicting evidence regarding the influence of ungulates on vegetation. However, the writer made several conlusions. Overgrazing indicated by Bird (1961) was probably limited to local areas. Fires referred to would not be prevalent in areas denuded by grazing simply because of the lack of fuel. The overgrazing indicated by Bird (1961) was probably not prevalent in the study area because summer concentrations of bison were not noted in this region. Grazing in the dormant season (winter) has less detrimental effect on range plants than spring and summer grazing (Sampson, 1952). Smoliak et al (1969) indicated that stocking rates may be much higher than normally recommended, without damaging the range, if grazing is limited to the season of complete dormancy. Fire was an important environmental factor in the development of the vegetational patterns of the study area. If summer grazing was not prevalent, the fuel required would be available during dry periods for fires to sweep the area

in summer and fall.

Domestic livestock were introduced to Alberta in the late 1800's and the early 1900's. The first known ranching operation using the study area was called the Imperial Ranching Company. The land was used as open range. Open range is used in the context that the land was used free of charges to whoever grazed it. The Burns ranching interests purchased the Imperial in 1911 and introduced fencing. The Dominion land survey was completed in 1907. Jim Walters and Tom Usher acquired the land lease from Burns in 1917, and operated it until 1920 when the ranch was divided. The study area was used by the Usher ranch until 1967. These ranchers, from 1917 to 1967, practised an extensive type of yearlong grazing management system. Since the study area was not located near a reliable source of water during spring and summer, grazing during the growing season was probably light. From 1967 to the present time the study area was reserved as a natural area. During this time the land was located in a far corner of a large field grazed at light rates. This land was available to grazing livestock but due to the location in the field it received very light use. In early 1970 the study area was fenced to exclude domestic livestock.

This area has been subject to fires started by lightning. Ranchers have attempted to control fires, but at times large areas were burned. The last reported fire swept over the study area in 1964.

During the period 1880 to 1895 the study area was influenced little by grazing animals. Bison became virtually extinct in the early 1880's and cattle had not yet been introduced. Fires caused by

lightning and the abundance of flamable fuels probably resulted in frequent widespread prairie fires. The range condition on the study area was probably good to excellent.

3. Geography, Soils, and Physiography

The study area lies in a section of the great plains physiographic region called the "Eastern Alberta Plain". This region slopes chiefly to the east. Bowser et al (1951) indicated the bedrock was of the Edmonton formation originating from the upper Cretaceous period dating back some 125 million years. Wonders (1969) found that the Edmonton formation was composed of sandstone, coal and minor bentonite. The surficial deposits resulted from glacial deposition of a ground moraine called Beaverhills moraine. The resulting topography was strongly rolling to hilly, primarily of the knob and kettle variety. Bowser et al (1951) indicated the till to be primarily of Edmonton origin with varying amounts of Bearpaw shale mixed in, in local spots.

According to Bowser et al (1951), the soils of the study area were dark brown soils developed on glacial till. Generally, the till was a brown to grey-brown color and of a sandy clay texture. It had a low to medium calcium carbonate content. The "Hughenden Loam" was the principle soil type in the area. Hughenden loam was a dark brown chernozem and an average profile was described by Bowser et al (1951) as follows:

Centimeters

10 A_1 - Dark brown, prismatic pH 7.0

8 A_3 - Brown to dark brown, prismatic pH 6.3

Centimeters

15 B_2 - Strong brown, prismatic to columnar, friable nuciform mesostructure, some staining in the cleavage lines

25 B_3 - Brown. Friable, with some vertical cleavage lines

Cca - at about 20-24 inches from the surface Low to medium lime

C - Brown sandy clay loam

Bowser et al (1951) indicated that depressions receive eroded material from the surrounding hills. They collect runoff which remains a few weeks. These depressions have a muck surface and a heavy gley horizon. These were black meadow soils described as depression podzols.

Moss (1955) reported that the *Populus tremuloides* grove belt of southwestern and central Alberta occupy the black soil zone. Coupland and Brayshaw (1953) indicated that the same areas in Saskatchewan are black in color. The southern part of the parkland exists, to some extent, on dark brown soils.

Moss (1955) suggested that black chernozemic soils originate under *Festuca scabrella* dominated grasslands, and were originally larger in area than now. These areas have been invaded by *Populus tremuloides* and the soils have been modified to grey-black soils.

Acton (1964) studied the role of topography on the formation of soils in the dark brown soil zone of Saskatchewan. On hummocky moraine he found calcareous dark brown soils on convex knolls where slopes were greater than 8 percent, orthic dark brown soils on the intermediate

slopes of 5 to 8 percent, and eluviated dark brown soils occupied the foot slopes. The depressional areas contained humic-eluviated gleysols and rego-humic gleysols. This indicated the soil catena in the dark brown soil zone resulting from topographic features of the hummocky moraine.

4. Fauna of the Area

Of the large numbers of animals reported for this area, only a few were observed. It is probable that only the more conspicuous species were noted during the study.

The Richardson ground squirrel *(Citellus richardsonii richardsonii* Sabine) was noted particularily because it commonly formed colonies on patches of native grasslands. These colonies were concentrated on south slopes and areas of heavy grazing. The striped ground squirrel *(Citellus tridecemlineatus tridecemlineatus* Mitchell) was noted occasionally. The white-footed mouse *(Peromycus maniculatus* Mearns) was not seen, but its activity was observed in the matted grassland vegetation. Evidence of the Richardson pocket gopher *(Thomomys talpoides talpoides* Richardson) was rarely noted in the native vegetation. Observations of the white-tailed prairie hare *(Lepus townsendii campanius* Hollister) were rare. Residents reported porcupine *(Erethizon dorsatum epixanthum* Brandt) regularly. The prairie coyote *(Canis latrans latrans* Say) was noted frequently. Members of the deer family were represented by the white-tailed deer *(Odocoileus virginianus dacotensis* Goldman and Kellogg) and the mule deer *(Odocoileus hemionus hemionus* Rafinesque). The white-tailed deer appeared more numerous than the mule deer.

Of the reptiles, only a few garter snakes *(Thamnophis sirtalis parietalis* Say) were noted. The leopard frog *(Rana pipiens* Schreber) was abundant around sloughs.

LITERATURE REVIEW

Recognition of the Fescue *(Festuca scabrella)* grassland as a distinct and important vegetation type came recently. Moss (1955) stated that "John Macoun (1882), usually a keen observer and accurate reporter, makes no mention of *Festuca scabrella* for our region; indeed, he seems to have confused this species with *Stipa spartea*. Macoun (1882) does recognize one of the chief tall dense grasses of the Cypress Hills plateau as a species of *Festuca*." Weaver and Clements (1938) failed to recognize the *Festuca scabrella* association in their Climax Formations of North America. Moss (1955) noted *F. scabrella* as one of the chief grasses in the parkland in 1932. Clarke et al (1942) recognized the dominance of *F. scabrella* in portions of the parkland, in their "Submontane" type called the *Festuca - Danthonia* association. Coupland and Brayshaw (1953) argued that *Festuca scabrella* communities should be considered as a seventh association of the grassland formation. Moss (1955) considered the *Festuca scabrella* grassland of the parkland of western Saskatchewan similar to that found in Alberta. Coupland and Brayshaw (1953) indicated that the importance of *F. scabrella* ranged from complete dominance in the northern areas of the parkland, to codominance with *Stipa spartea* var. *curtiseta* in the more southerly areas.

The *Festuca scabrella* association of the parkland differed from that found in other locations in several ways. Coupland and Brayshaw (1953) concluded that the abundance of *Potentilla fruticosa* characterized the association in the Cypress Hills, but it was absent in the parkland region. Moss (1955) reported that *Festuca idahoensis* and *Danthonia parryii* were the chief species associated with *Festuca scabrella* in southwestern Alberta. These were not reported for the parkland region. Other species important in the Palouse prairie of the northern United States such as *Lithospermum ruderale*, *Geranium viscosissimum*, and *Balsamorhiza sagittata*, were found in southwestern Alberta (Moss, 1944), but were not reported by Coupland and Brayshaw (1953) for the parkland region.

Moss and Campbell (1947) listed species found in north only and south only sections of the *Festuca scabrella* association. This list indicated there are many plants common in the fescue grassland to the south and not found in the parkland fescue grassland.

Festuca scabrella, a dominant species in the grassland areas of the parkland, was widely distributed in North America. Johnston (1958) reported its presence in areas from Newfoundland to British Columbia and from the Yukon to Colorado. *Festuca scabrella* was dominant or codominant in grassland areas from the interior of British Columbia to southern Manitoba and from south-central Alberta to northern Montana. Moss (1955) indicated the *Festuca scabrella* association occupied the black, and part of the dark brown soil zones in southwestern and central Alberta, as well as in the Cypress Hills. Coupland and Brayshaw (1953) concluded the *F. scabrella* dominated areas lie north of the mixed prairie in western Saskatchewan, but it loses

dominance proceeding eastward. Tisdale (1947) reported *Festuca scabrella* dominating the upper grassland zone (800 - 1,000 m. above sea level) in the moister areas, with *Agropyron spicatum* dominating the drier parts, in the interior of British Columbia. Blood (1966) recorded the presence of *F. scabrella* dominated grasslands in the western portions of Riding Mountain National Park in Manitoba. He indicated the total area was not great. The *F. scabrella* dominated grassland was probably more extensive in the past, but it has been invaded by *Populus tremuloides* and *Picea glauca* forest. Lynch (1955) recognized the *Festuca scabrella* association in Glacier County, Montana. He called it the climatic climax grassland in the *Populus tremuloides* groveland. Cosby (1965) stated, "Local areas exist in North Dakota having rough fescue dominated plant communities. Some of these are sufficient to be mapped as a distinctive grassland type."

1. Plant Communities

Moss (1955) described the parkland as a grassland-woodland ecotone. Coupland and Brayshaw (1953) considered the parkland to consist of an intermingling of grassland and forest communities. They interpreted the ecotone to occur around each grove of *Populus tremuloides*. This reflected the levels at which researchers may investigate the parkland areas. Moss described an overall picture of the area, whereas Coupland and Brayshaw described the parklands on a more detailed level. The *Populus tremuloides* groves or bluffs occupied the moister areas, and the grassland occupied the drier sites. Under the heading of primary succession, Coupland (1961) mentioned several plant communities.

These communities are the sedge-meadow stage of sedges and grasses, the shrub stage with *Salix* spp., the tree stage of *Populus tremuloides* the grassland-shrub stage with *Symphoricarpos* and *Elaeagnus* spp., the *Festuca scabrella* prairie, the *Stipa-Agropyron* faciation, the *Stipa-Bouteloua-Agropyron* preclimax, and the *Agropyron-Muhlenbergia* facies. Coupland and Brayshaw (1953) found that the postclimax communities of sedge-meadows, *P. tremuloides* and *Salix* spp. occur in the depressions, and preclimax communities of mixed prairie are located on exposed locations. In a discussion of the *Stipa-Agropyron* faciation, Coupland (1950) indicated that in the dark brown soil zone the *Stipa-Bouteloua* type occurs on the tops of the knolls and the *Stipa-Agropyron* occurs on the intermediate slopes.

Local groves of aspen and willow were characteristic of the mixed soils, indicating an increase in water content of the soil. Moss (1955) stated: "In Clementsian language the fescue community is described as a postclimax to the *Stipa-Agropyron* faciation of the mixed prairie, the latter commonly occupying exposed locations within the aspen grove region, such as south-facing slopes and the tops of knolls; the fescue community is preclimax to the aspen forest."

Recent interest in sloughs (Walker and Coupland, 1970; and Walker and Coupland, 1968) has led to a greater understanding of these wetland areas. These sloughs are depressional areas containing standing water for at least several weeks in the spring around which the *Salix* spp. and *P. tremuloides* groves are found. The five environmental factors generally regarded as important in the ecology of sloughs are: the moisture regime, the salinity of the water, the edaphic complex, plant competition, and disturbance. Walker and Coupland (1968)

suggested that due to the fluctuation of water level, plants must be capable of extremely rapid growth to form stands when conditions change. Stands of these plant associations are constantly shifting as the water level fluctuates.

2. Ecological Change Related to Range Condition

Range condition has come to have two distinctly different meanings. Sampson (1952) defined range condition as "the state of health of a specific range area and is expressed as the amount of forage that an area will produce under the best practical management." The popular usage of the term refers to the forage production of the current year compared to last year or to the average year. Range condition discussed here refers to the long term state of range health, rather than the favorableness of the season. Parker (1954) stated that, "range condition classes are in reality successional stages of plant communities". Dyksterhuis (1949) maintained that a rational way to detect overgrazing is to recognize the replacement of some plant species by others. This requires a knowledge of autecology -- the study of individual species, and synecology -- the study of vegetation as a plant community in relation to its environment. Disturbances such as fire, cultivation and overgrazing, cause changes in plant composition. When the disturbing force is removed, the vegetation shifts toward climax, or the highest development possible under the prevailing climate. This is secondary succession. Range condition classes may be set up to correspond to a stage or stages in secondary succession as determined by grazing use.

Dyksterhuis (1949) assumed that climax for a site can be described from the original vegetation (relic areas). Differences in range condition may be recognized by comparing the present vegetation with climax vegetation. Plant species may react differently in response to grazing. Dyksterhuis (1949) maintained that plant species may be grouped ecologically by their reactions to grazing. These have been described as: decreasers -- species that decrease in relative abundance under grazing, increasers -- species that increase in relative abundance as the decreasers decline, and invaders -- species not components of the community that invade as the increasers and decreasers decline.

The reaction of plant species to grazing has been reported in several studies on the Canadian prairies. Moss (1955) suggested that grazing or mowing grasslands in the *Festuca scabrella* association results in a marked reduction in *F. scabrella* and an increase in *Agropyron trachycaulum, Stipa spartea* var. *curtiseta, Koeleria cristata, Danthonia* spp., *Carex* spp. and certain forbs. Blood (1966) indicated that heavy cattle grazing has reduced the original fescue prairie to a bluegrass-dandelion-shrubby cinquefoil association in Riding Mountain National Park, Manitoba. Coupland (1961) maintained that heavy grazing on *Stipa-Agropyron* vegetation causes an increase in relative abundance of low-growing *Bouteloua gracilis* at the expense of the taller mid-grasses like *Stipa* spp., *Agropyron* spp., etc. The degree of grazing may produce either a *Stipa-Bouteloua-Agropyron*, a *Stipa-Bouteloua*, or a *Bouteloua-Stipa* dominated vegetation. Under grazing, the fescue prairie produces an increase of the plant species characteristic of the *Stipa-Agropyron* faciation of the mixed prairie including *S. spartea* var. *curtiseta, S. comata, A. dasystachyum, A. smithii, B. gracilis,*

Koeleria cristata. Walker and Coupland (1968) stated that the common effect of grazing in the *Carex* depressions was the increase of *Poa palustris*, to form pure stands. *Glyceria grandis* and *Beckmannia syzigachne* were favored by grazing. Johnston et al (1966) specifically listed plants under the increaser, decreaser, and invader classification on a regional basis. Smoliak et al (1969) listed the amount of each species found in the original or climax vegetation.

METHODS

Coupland (1961) indicated that the continuum concept has great value for the purpose of defining the nature of vegetation. For mapping vegetation, it may be more practical to separate the continuum into discrete units; an example being the range sites of Dyksterhuis (1949). In practise, the management of a continuum is very difficult. In range management the ecology of grazing animals has to be considered as well as the ecology of the vegetation. Animals show preferences for certain plant communities. In vegetational studies it is more efficient to stratify prior to sampling (Daubenmire, 1959). If vegetation can be stratified into plant groupings sampling can be restricted to representative areas of each group. This method saves time and reduces unnecessary sample collection.

1. Reconnaissance (1968 & 1969)

A. 1968

A preliminary examination of the grassland of the study area

using the point transect method of Clarke et al (1942) was made in 1968. The 800 m. transect line ran from southwest to northeast across the study area. The straight line transect was located to include only grassland types. The only difference in methodology from that described by Clarke et al (1942) was that a 30 point frame having pins spaced at 2.5 cm. intervals was used instead of a 10 point frame with the pins spaced further apart.

B. 1969

After examination of the data collected in 1968, it was decided that a more extensive study was required to understand the variability of species and herbage yield encountered. A review of sampling methods led to the selection of the canopy-coverage method of vegetation analysis described by Daubenmire (1959). The canopy-coverage method was to be supplemented by a clipping program. The reasons for selecting this method were: it facilitates the examination of plant groupings of different life forms and ages, and compares them on a common basis; it yields sufficient accuracy with a minimum field time; it allows the use of a two-dimensional plot which is considered superior to a point; the sampling accuracy can be increased by increasing the number of observations; the clip procedure allows herbage yield to be measured and permits comparisons to be made between canopy coverage and herbage production techniques of vegetation analysis.

A preliminary study was conducted in August 1969. The area was examined by making ocular canopy coverage estimates by species and by clipping the herbage.

Canopy coverage is defined as "the percentage of ground covered when a polygon, drawn around the extremities of the undisturbed canopy of each plant is projected on the ground and all projections on a given area are summed" (Daubenmire, 1959).

In each of five stands (a stand is a concrete example of the community), two rectangular 0.25 square meter plots were randomly located and clipped at ground level. The plant material was separated into the current growth of shrubs, forbs, grass and grass-likes. This was air-dried and weighed. In each stand, eight 0.1 square meter plots were randomly located and the canopy coverage of each species was recorded according to the procedure outlined by Daubenmire (1959).

The herbage yield data was analyzed to estimate the number of plots required to give an adequate sample in 1970. The plant species data was analyzed by the construction of an association table to test the hypothesis that the selected areas represented different plant communities.

2. Quantitative Analysis 1970

Several plant communities were tentatively defined from the 1969 reconaissance data. The boundaries of stands in each community in the study area were mapped using the 1970 data and 1970 aerial photography. To obtain a measure of species presence and dominance, the canopy coverage was estimated in 20x50 cm. plots. To obtain an estimation of herbage yield, some of the same plots were clipped, air-dried and weighed.

The preliminary (1969) sampling indicated that thirty-two 20x50 cm. plots were adequate to give a mean annual herbage production

having a standard error of the mean of ±10 percent with an 80 percent probability. Forty 20x50 cm. plots gave the required precision in canopy coverage for all species in each stand. Five stands of each plant community were selected for this study. The *Carex* communities were under water in 1970 so yield data could not be collected. The herbage production in *Salix* and *Populus* communities was found to be so low in 1969 that further studies were not warranted.

The stands least affected by grazing disturbance were selected to represent the communities of the study area. Within the boundaries of each community, forty observations recorded the presence and coverage class for each species. The tree, shrub and herb layer were studied. The values used for canopy coverage classes are as follows:

Class	Range (%)	Midpoint (%)
1	0-1	0.5
2	1-5	3.0
3	5-25	15.0
4	25-50	37.5
5	50-75	62.5
6	75-95	85.0
7	95-100	97.5

The main transect line was placed along the greatest length of line that could be drawn across the stand.

The 24.4 m. sample transect line was located in the central portion of this longest transect line (Figure 1). Four secondary transect lines were placed at right angles to the main transect line equidistant from each other. Each secondary transect line was 3 or 6 m.

long, depending upon the width of the stand. Along each secondary transect line 10 plot observations were placed equidistant along the 3 or 6 m. line (Figure 2). These were made first on the left and then on the right of the line. Plots 2-9 inclusive were harvested at ground level. Plots 5 and 9 were sorted by species to current growth, litter, and old wood (Figure 2). This was repeated over the remaining three secondary transect lines. Five representative stands of each community were sampled in this manner.

Figure 1. Transect layout

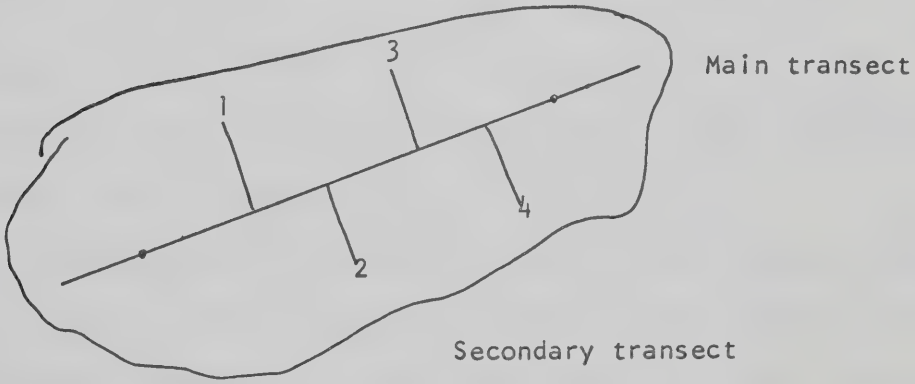
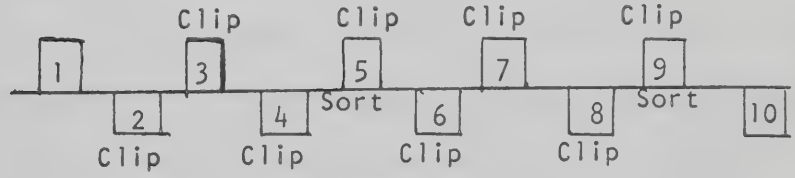


Figure 2. Secondary transect line and plot location



The herbage from each plot harvested was placed in paper bags and plot numbers 5 and 9 were sorted to species in the field. The clipped herbage was air-dried and weighed. This method was followed for the four

communities: *Symphoricarpos occidentalis*, *Festuca scabrella*, *Stipa-Festuca* and the *Stipa-Artemisia*. A reconnaissance method of describing vegetation without clipping was followed on the remaining communities. This involved the mapping of each stand and randomly selecting five. The canopy cover of the total area of the stand was estimated for each species noted, using the same canopy coverage classes as the detailed method.

To obtain more information on the *Symphoricarpos* dominated communities, two *Symphoricarpos* stems from each of 45 stands were randomly collected and the growth rings were counted. The *Populus* community was divided into young and mature stands. From five stands of each community twenty *Populus tremuloides* trees were randomly selected, cut down, the height measured and a cross section of the stem collected. The growth rings were counted at a later date.

To determine the successional status of the *Populus tremuloides* and *Salix petiolaris* communities, a comparison was made between the area occupied by these communities in 1907 versus 1966. The legal land survey field notes of Cautley (1907) measured the width of "poplar and willow brush" that crossed each survey line. Forty samples, each one mile in length, were randomly selected for comparison. The same lines were then located on aerial photos taken in 1966 and the *Populus* and *Salix* communities measured. The two figures were compared to establish whether these woody species have increased, decreased, or continue to occupy the same area, over a 59-year period.

In 1970 a soil profile description was made in each sampled stand. In the center of the transect line a soil pit was dug to the parent material. The location was selected near the center of the stand

to represent the stand sampled, rather than a transitional type at the edge of the stand. The soil was classified using the System of Soil Classification for Canada (Canada Soil Survey Committee, 1970).

RESULTS

1. 1968

Table 3 represents a composite mean basal area cover of the grassland in the study area. The grassland was dominated by *Festuca scabrella*. Another important plant was *Stipa spartea* var. *curtiseta*. *Carex* spp. gave an aggregate basal area second only to *F. scabrella*. The *Carex* spp. are lower-growing plants than *F. scabrella* and *S. spartea* var. *curtiseta*. The grass species dominate and greatly influence the *Carex* spp. The grassland of the study area closely resembles the *Festuca scabrella* association of the aspen grove region of Saskatchewan described by Coupland (1961). Table 4 compares the grassland of the study area with the *Festuca scabrella* association described by Coupland (1961). The sampling methods used by Coupland and those used in the study area are approximately the same. The Saskatchewan data closely resembles that of the study area.

Four grasses: *Koeleria cristata, Helictotrichon hookeri, Danthonia intermedia* and *Muhlenbergia squarrosa,* were not found by the point sampling method in the study area but did occur in Saskatchewan. These species did occur in the study area but were in such small quantities that they did not show up in the sample. The difference in the abundance of these four grasses was one of the main differences between the study area and the parkland in Saskatchewan.

Table 3. Basal area and percent composition as indicated by the point transect method, 1968.

Species	Hits out of 3600 Points	Basal Area (%)	Composition (%)
Festuca scabrella	101	2.8	37.4
Stipa spartea var. *curtiseta*	56	1.6	20.7
Bouteloua gracilis	4	0.1	1.5
Agropyron spp.	3	0.1	1.1
Muhlenbergia cuspidata	1	-	-
Poa spp.	1	-	-
Juncus balticus	1	-	-
Carex eleocharis	51	1.4	18.9
Carex spp.	31	0.9	11.5
Selaginella densa	8	0.2	3.0
Symphoricarpos occidentalis	1	-	-
Geum triflorum	1	-	-
Achillea millefolium	2	0.1	0.7
Erigeron spp.	2	0.1	0.7
Anemone spp.	3	0.1	1.1
Galium boreale	1	-	-
Antennaria spp.	1	-	-
Chrysopsis villosa	1	-	-
Rosa spp.	1	-	-
Total	270	7.4	100.0

Table 4. A comparison of the *Festuca scabrella* association in Saskatchewan with that of the study area.

Species	Cover Composition: Coupland (1961) 1950 (%)	Coupland (1961) 1957 (%)	Study Area (Table 1) (%)
Festuca scabrella	36.3	43.1	40.6
Carex spp.	27.4	25.3	32.9
Stipa spartea var. *curtiseta*	15.5	12.5	22.5
Agropyron spp.	3.1	8.8	1.2
Bouteloua gracilis	1.5	0.4	1.6
Koeleria cristata	10.9	5.4	-
Helictotrichon hookeri	3.8	3.1	-
Danthonia intermedia	1.0	-	-
Muhlenbergia squarrosa	0.5	0.8	-
Other grasses	-	0.6	1.2
Total	100	100	100

The major criticism of this method of sampling is that it gives only a composite average. The location of the transect line across rolling topography, such as in this study area, is very critical. If more than the actual area of south-facing slopes were sampled, the results could be swayed in favor of *Stipa spartea* var. *curtiseta;* if more north-facing slopes were sampled, the basal area of *Festuca scabrella* would be favored. This may account for some of the differences indicated in Table 4.

Definite vegetational patterns were recognized while in the field in 1968. Therefore, each of these characteristic areas should be sampled intensively and described in proportion to the total area they cover. This would give a more detailed characterization of the vegetation

permitting the development of more intensive range management plans. The point transect method of Clarke et al (1942) is adequate for measuring these variations amongst grass species, but it is not suitable for measuring the ecological importance of forbs and shrubs. For this reason, the canopy-coverage method described by Daubenmire (1959), and an estimate of herbage yield, were used to gather further preliminary data in 1969.

2. 1969

The study area is a mosaic of the stands of different plant communities. Tables 5 and 6 describe the species composition and herbage yields of the discrete units or plant communities identified. The plant communities are arranged on a wet to dry moisture continuum.

The *Carex atherodes* community occurs in dish-like depressions that are covered with water annually for a few weeks in a dry year, to a full summer in a wet year. Stands of this community may be identified by moisture-loving plants, such as *Beckmannia syzigachne, Glyceria grandis, Sium suave,* and *Carex atherodes*. The yield of the *C. atherodes* community fluctuates, depending upon the duration of deep water during the growing season. In 1969, when herbage production was recorded, the water had disappeared by late June. In other years, when surface water remained for a longer period, the annual yield was much reduced. Walker and Coupland (1970) concluded that plant groups are continually shifting from year to year, depending on water levels, provided the salinity level is held constant.

Table 5. Summary of canopy-coverage % (1969) for each tentatively identified plant community

Species	Plant Community					
	Carex atherodes	*Salix petiolaris*	*Populus tremuloides*	*Symphoricarpos occidentalis*	*Festuca scabrella*	*Stipa spartea*
Beckmannia syzigachne	6.7					
Glyceria grandis	5.7					
Hordeum jabatum	0.4					
Sium suave	0.9					
Carex atherodes 1/	84.7	30.2				
Mentha arvensis	3.5	0.6				
Polygonum spp.	5.5	0.8				
Cirsium arvense	0.8	10.3	1.5			
Poa spp.	2.7	10.5		0.9		
Muhlenbergia spp.	0.4	4.8				1.6
Juncus balticus	10.2	4.4	1.8	2.5		
Calamagrostis spp.	8.0	36.9	2.5	0.4		
Aster spp.		0.4				
Salix spp. > 4'		79.4				

1/ *Carex atherodes* is the dominant species in this group, small amounts of *C. rostrata* and *C. arthrostachya* occur

Table 5. (Continued).

Species	Plant Community					
	Carex atherodes	*Salix petiolaris*	*Populus tremuloides*	*Symphoricarpos occidentalis*	*Festuca scabrella*	*Stipa spartea*
Salix spp.		0.6				
Taraxacum officinale		0.6				
Populus tremuloides		2.3	78.3			
Petasites spp.		0.8	0.4			
Solidago spp.		13.3		2.4	0.1	
Fragaria virginiana		0.8	1.2		0.1	
Achillea millefolium		0.4	0.4	0.8	1.6	
Galium boreale		1.7	4.2	3.7	3.2	0.8
Symphoricarpos occidentalis		0.8	56.7	74.6	0.4	
Potentilla spp.		0.8			0.9	0.5
Astragalus spp.		0.4			0.4	0.1
Sonchus arvensis		4.6		0.4		
Geranium bicknellii			0.9			
Populus tremuloides <4'			41.1			
Carex spp.			15.8	37.1	22.8	35.7

Table 5. (Continued).

Species	Plant Community					
	Carex atherodes	*Salix petiolaris*	*Populus tremuloides*	*Symphoricarpos occidentalis*	*Festuca scabrella*	*Stipa spartea*
Agropyron spp.			6.9	5.0	1.6	7.9
Rosa spp.			13.5	2.1	4.7	3.0
Festuca scabrella			6.2	56.7	94.4	
Danthonia intermedia			0.4	1.9	0.8	
Artemisia ludoviciana			0.4	7.5	0.4	
Stipa spartea var. *curtiseta*				3.9	4.5	25.8
Artemisia frigida				0.8	0.5	18.9
Erigeron spp.				0.4		
Vicia sparsifolia				0.4		
Erigeron caespitosus					0.9	
Geum triflorum					1.3	
Antennaria spp.					0.6	
Anemone patens					0.1	
Androsace septentrionalis					0.4	0.1
Chrysopsis villosa					0.9	0.5

Table 5. (Continued).

Species	Plant Community					
	Carex atherodes	*Salix petiolaris*	*Populus tremuloides*	*Symphoricarpos occidentalis*	*Festuca scabrella*	*Stipa spartea*
Koeleria cristata						3.7
Selaginella densa						2.7
Haplopappus spinulosus						0.4
Sphaeralcea coccinea						2.9
Lepidium spp.						0.4
Phlox hoodii						0.4
Lygodesmia juncea						0.4
Bouteloua gracilis						26.6

Table 6. Annual herbage production of six plant communities, 1969

Kilograms per Hectare

Community		Mean yield	Standard error
Carex atherodes			
	grass 1/	5176	
n=10	forbs	56	
	shrub 2/	---	
		5232	± 912
Salix petiolaris			
	grass	310	
n=10	forbs	218	
	shrub	---	
		528	± 64
Populus tremuloides			
	grass	154	
n=10	forbs	82	
	shrub	282	
		518	± 76
Symphoricarpos occidentalis			
	grass	978	
n=10	forbs	48	
	shrub	1042	
		2068	± 208
Festuca scabrella			
	grass	1944	
n=10	forbs	46	
	shrub	22	
		2012	± 88
Stipa spartea var. *curtiseta*			
	grass	926	
n=10	forbs	226	
	shrub	12	
		1164	± 108

1/ includes all grass and grass-like plants

2/ includes only the annual growth not including the annual increase in woody stems

The second community encountered consists of *Salix petiolaris* dominated areas around the drier portions of the *Carex atherodes* community, and often forms a transition between the slough and the *Populus tremuloides* communities. Fluctuating water levels in the *Carex atherodes* community also affect the boundary and extent of the *Salix petiolaris* community. During years of low water levels, *S. petiolaris* invades the *Carex atherodes* community. During years of high water levels, the *Salix petiolaris* plants in the *Carex* community die. The most striking characteristic of this community is the high cover of *S. petiolaris* (80 percent). The canopy of the *S. petiolaris* reduces the light received on the ground and probably accounts for the low annual yield at ground level. *Salix petiolaris* competes with the ground plants as well. *Salix petiolaris* communities share *Mentha arvensis, Cirsium arvense* and *Calamagrostis* spp. with the *Carex atherodes* community (Table 5). The presence and cover of *C. atherodes* and *Calamagrostis* spp. provide similarities to the *Carex atherodes* community.

The *Populus tremuloides* community occupied the area between the *S. petiolaris* and the *Festuca scabrella* grassland. The main difference from the surrounding vegetation is the higher cover of *P. tremuloides* and the presence of *Geranium bicknellii*. Low cover plants can hardly be used to characterize this community, because of the low intensity sampling procedure used. The *Populus tremuloides* community shares the presence of *P. tremuloides, Fragaria virginiana* and *Galium boreale* with the *Salix petiolaris* community. The community also has *Cirsium arvense, Juncus balticus* and *Calamagrostis* spp. which occur in both the *Salix petiolaris* and *Carex atherodes* communities. The annual

yield compares closely to that of the *Salix petiolaris* community. Here, as with *S. petiolaris*, the lack of light, caused by the upper stratum, reduces herbage yield on the ground.

The shrub-dominated *Symphoricarpos occidentalis* community appeared in many varied locations over the study area. Here, the distinguishing characteristic is the high cover of the shrub *S. occidentalis*. A number of species of the *Symphoricarpos* community occurred in the *Festuca scabrella* and *Populus tremuloides* communities indicating the affinity of *Symphoricarpos* to those communities. The annual production was substantially greater in the *Symphoricarpos occidentalis* community, than under *P. tremuloides* (Table 6). One reason for this difference was that the current growth of the shrub was harvested while it was not possible to harvest the annual growth of *P. tremuloides*.

The *Festuca scabrella* community is characterized by a high canopy cover of *F. scabrella*. The *Carex* species in this community include *C. praticola*, *C. lasiocarpa* and *C. obtusata*. A species found only in this community was *Geum triflorum*. The *Festuca scabrella* community shares many species with surrounding communities. The yield of grass and grass-like plants was second only to the *Carex* sloughs. This community covers over 50 percent of the total area and occupies a mesic location in the landscape.

The *Stipa spartea* var. *curtiseta* community occupies the hilltops and upper south-facing slopes. This community occurs on the most xeric locations. It is characterized mainly by *Bouteloua gracilis* and plants such as *Phlox hoodii*, *Sphaeralcea coccinea* and *Haplopappus spinulosus*. These areas were described in Saskatchewan by Coupland (1961)

as the *Stipa-Bouteloua* faciation of the Mixed Prairie Association. With the exception of the *Salix petiolaris* and *Populus tremuloides* communities, the annual herbage production of the *Stipa* community was lowest. In the *Salix petiolaris* and *Populus tremuloides* communities, low harvestable yields were caused by light limitation and by woody plant competition. The low yields of the *Stipa spartea* var. *curtiseta* community was attributable to the lack of effective moisture.

Annual herbage production averaged 5232 Kg./ha. on the *Carex atherodes* community. This is ten times the herbage production found in the *Salix petiolaris* and *Populus tremuloides* communities, two and one-half times greater than that of the *Festuca scabrella* and *Symphoricarpos occidentalis* communities, or five times that of the *Stipa spartea* var. *curtiseta* community. This is due, primarily, to the moisture availability in the *Symphoricarpos occidentalis*, *Festuca scabrella* and *Stipa spartea* var. *curtiseta* communities and to the reduced light caused by the *Salix petiolaris* and *Populus tremuloides* canopy in those communities.

The six plant communities outlined in this preliminary study provide a variety of habitat conditions for the animal components of the ecosystems. Since the animals have a choice, differential preferences are made for one plant community over another. Because of the differential preferences displayed by grazing animals for the plant communities, further studies of the vegetation as discrete communities are justified.

3. 1970

a. The *Carex atherodes* Community

The *Carex* community occupied the depressions associated with rolling topography. These depressions held water during part of the growing season. The *Carex* community covered 11.1 percent of the total study area. Table 7 lists some of the conspicuous plants located in these depressions. *Carex atherodes* with *C. rostrata* and some *C. arthrostachya* dominated the vegetation in most depressions.

The vegetation in these areas was extremely variable. During 1970 all these depressions retained water above the soil surface until August. Shallow water favored *Carex atherodes*, while deeper water favored *Glyceria grandis*, and in some areas *Typha latifolia*, *Scirpus* spp. and *Sium suave*. The coverage of plants in these areas fluctuates depending on the depth of water and the length of time the water remains during the summer. Herbage yield in 1970 was very low because of the deep water covering the stands during the growing season.

Table 7. Canopy cover of plant species in the *Carex atherodes* community, 1970. (n = 5)

Species	Canopy Cover (%)
Carex 1/	90
Calamagrostis inexpansa	61
Beckmannia syzigachne	10
Agrostis alba	6
Glyceria grandis	6
Stachys palustris	2
Hordeum jabatum	1
Sium suave	1
Sonchus arvensis	1
Typha latifolia	0.5
Scirpus spp.	0.5
Salix petiolaris	0.5

b. The *Salix petiolaris* Community

This community was identified by a high cover of the shrub *Salix petiolaris*. Table 8 lists the species identified in this community. Understory plants that contributed one percent or more canopy cover were: *Sonchus arvensis, Rosa woodsii, Carex praticola, C. rostrata, C. atherodes, Solidago pruinosa, Circium arvense, Vicia americana, Agrostis* spp., *Symphoricarpos occidentalis, Calamagrostis* spp. and *Lathyrus* spp.

Stands of the *Salix petiolaris* community covered 6.8 percent of the study area or 4.37 hectares (10.8 acres). This community formed

1/ Predominantly *C. atherodes* with *C. rostrata, C. arthrostachya.*

rings around depressions, occurred as clumps around depressions or along drainages, and was generally restricted to moister areas associated with rolling topography. In southwestern Alberta, Johnston and Smoliak (1968) considered *Salix* as a forerunner to establishment of groves of *Populus*. The *Salix* community shared the presence of several plant species with the *Carex* community. These included *Salix petiolaris, Sonchus arvensis, Beckmannia syzigachne, Calamagrostis* spp., *Carex rostrata* and *C. atherodes*. The boundaries of stands of the *Salix* community fluctuated in response to water levels in the depressions. There was visual evidence that *Salix* had invaded the *Carex* community during periods of low water levels and had died when water levels rose.

The soils found under the willow were all rego-humic gleysols with one profile being carbonated and another salinized. After standing a few hours the soil pits filled with water.

c. The *Populus tremuloides* Community

The *Populus tremuloides* community was obviously distinct from the grassland and shrub communities in the study area. It was the only community dominated by trees. The *P. tremuloides* community covered 9.1 percent of the study area or 5.9 hectares (14.58 acres). This area was made up of 42 groves ranging in size from 0.02 to 0.5 hectares. The vegetation in this community is described in Table 9. This community was arbitrarily divided into mature and young stands. The mature stands had *P. tremuloides* trees that ranged from 5 to 16 m. tall and the stems were 5 to 30 cm. diameter at breast height (DBH).

Table 8. Canopy cover of plant species in the *Salix petiolaris* community, 1970. (n = 5)

Species	Canopy Cover (%)
Salix petiolaris	88
Sonchus arvensis	10
Rosa woodsii	9
Carex praticola	7
Agrostis spp.	5
Symphoricarpos occidentalis	5
Vicia americana	4
Lathyrus spp.	4
Cirsium arvense	3
Solidago pruinosa	2
Calamagrostis spp.	2
Carex rostrata & atherodes	1
Plantago major	0.7
Anemone canadensis	0.6
Smilacina stellata	0.6
Potentilla spp.	0.5
Juncus balticus	0.5
Stachys palustris	0.5
Bromus ciliatus	0.5
Galium boreale	0.5
Populus tremuloides	0.4
Astragalus canadensis	0.3
Taraxacum officinale	0.3

Table 8. Continued.

Species	Canopy Cover (%)
Fragaria spp.	0.3
Achillea millefolium	0.3
Agropyron spp.	0.3
Alopecurus aequalis	0.2
Beckmannia syzigachne	0.2
Artemisia ludoviciana	0.2
Hordeum jabatum	0.1
Campanula rotundifolia	0.1
Cirsium vulgare	0.1

The trees in the young stands ranged from 1 to 8 m. tall and the stems were 1 to 7 cm. DBH. The young stands were located around the grassland edge of the mature stands.

The tree community tended to form incomplete rings around the depressional areas. The greatest development of the *Populus* community tended to be located on the south side of these depressions on the north-facing slopes. The north side of the depressions (south-facing slopes) had the least area covered by *Populus*. The young stands had their largest areas on the south side, upslope from the mature stands.

The vegetation is dominated by a tree canopy cover of 90 percent. The shrub, *Symphoricarpos occidentalis*, averaged 69 percent canopy cover. *Rosa woodsii* was present in smaller amounts. Other plants which had a canopy cover of one percent or more include: *Galium boreale*,

Table 9. The canopy cover of the plant species in the *Populus tremuloides* community, 1970. (n = 5)

Species	Canopy Cover	
	Mature (%)	Young (%)
Populus tremuloides	90	93
Symphoricarpos occidentalis	69	69
Rosa woodsii	11	1
Galium boreale	6	0.5
Calamagrostis inexpansa	6	1
Vicia americana	6	1
Carex spp. 1/	5	5
Fragaria virginiana	0.4	1
Agropyron subsecundum	0.4	0.5
Artemisia ludoviciana	0.4	0.3
Smilacina stellata	0.4	-
Taraxacum officinale	0.4	-
Campanula rotundifolia	0.4	-
Viola spp.	0.4	-
Anemone canadensis	0.4	-
Ribes oxyacanthoides	0.3	-
Hordeum jabatum	0.3	-
Erigeron philadelphicus	0.2	0.3
Cirsium arvense	0.2	0.2

1/ *Carex* species of which *C. praticola, C. lasiocarpa* were identified.

Table 9. Continued.

Species	Canopy Cover	
	Mature (%)	Young (%)
Carex spp. 1/	0.2	-
Stachys palustris	0.2	-
Sonchus arvensis	0.2	-
Thalictrum venulosum	0.2	-
Potentilla spp.	0.2	-
Lathyrus spp.	0.2	-
Achillea millefolium	0.1	0.2
Glyceria grandis	0.1	-
Agrostis scabra	-	0.3
Erysimym cheiranthodes	-	0.2
Juncus balticus	-	0.2
Festuca scabrella	-	1.0

Calamagrostis inexpansa, *Vicia americana*, *Fragaria virginiana*, *Carex praticola*, and *Carex lasiocarpa*. Certain generalizations may be made about the mature versus young *Populus* stands. Plants characteristically found under only the mature *Populus* stands include: *Ribes oxyacanthoides*, *Smilacina stellata*, *Thalictrum venulosum*, and *Lathyrus* spp. (Table 9). The young *Populus* stands usually contained some of the plant species usually found in the *Festuca* grassland.

An analysis of forty miles of transect lines near the study area covered by the legal land survey of Cautley (1907) revealed that

1/ *Carex* species of which *C. atherodes* was identified.

0.2 percent of the area was covered by *Populus*. The same transects were analyzed on the aerial photographs taken in 1966. This revealed that *Populus* now occupied 3.4 percent of the area. The tree community dominated by *Populus tremuloides* had increased by about 1700 percent between 1907 and 1966 even though the community continues to occupy a relatively small portion of the study area. The growth ring analysis presented in Figures 3 and 4 reveal some of the major periods when rapid tree invasion occurred. The age distribution of the trees, represented by growth rings, indicated that invasion was concentrated into three periods. These periods were approximately 50 to 60, 20 to 30, and 5 to 10 years ago. Apparently 1910 to 1920, 1940 to 1950, and 1960 to 1965 were the periods in which the most active tree invasion occurred. There was no correlation between tree establishment and annual precipitation (Figure 5).

Maini (1960) indicated that *Populus tremuloides* clones, on medium textured soils in the dark brown soil zone, exhibited a rate of invasion of 1.0 to 2.5 feet per year. He reported that suckering is stimulated when temperatures and moisture conditions are favorable. He suggested that *Populus tremuloides* becomes established during moist periods, but dies out during extended drought. A succession of dry years has resulted in death of natural stands of trees. Maini (1960) concluded that *Populus tremuloides* groves have reached their potential limit on medium textured dark brown soils and that since the cessation of prairie fires the invasion has taken place in a limited manner. Johnston and Smoliak (1968) reported there was little brush on the rangelands of southwestern Alberta 85 years ago. They go on to say that "Our observations indicate that brush invasion is still actively underway

Figure 3. The number of trees and number of growth rings in older *Populus tremuloides*.

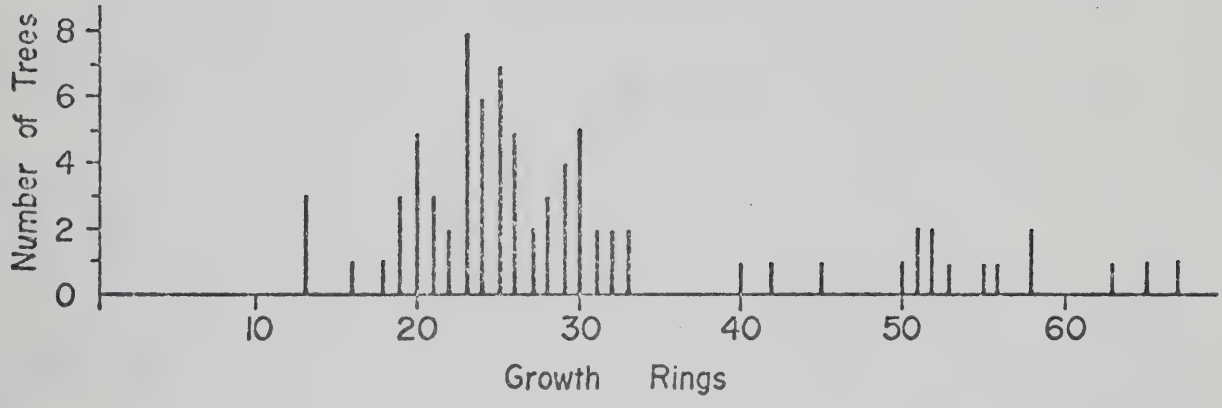


Figure 4. The number of trees and number of growth rings in the young *Populus tremuloides*.

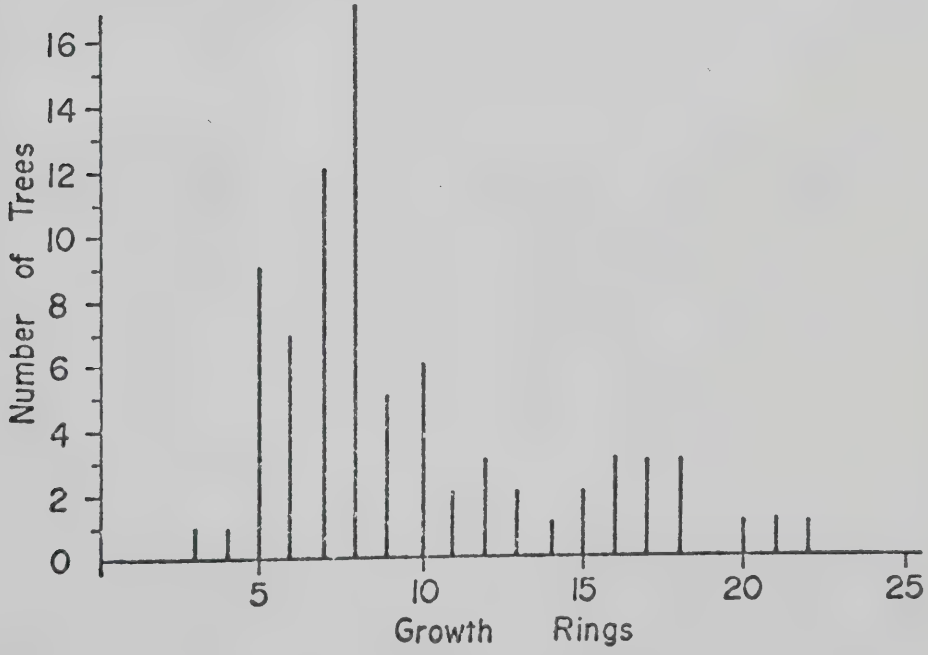
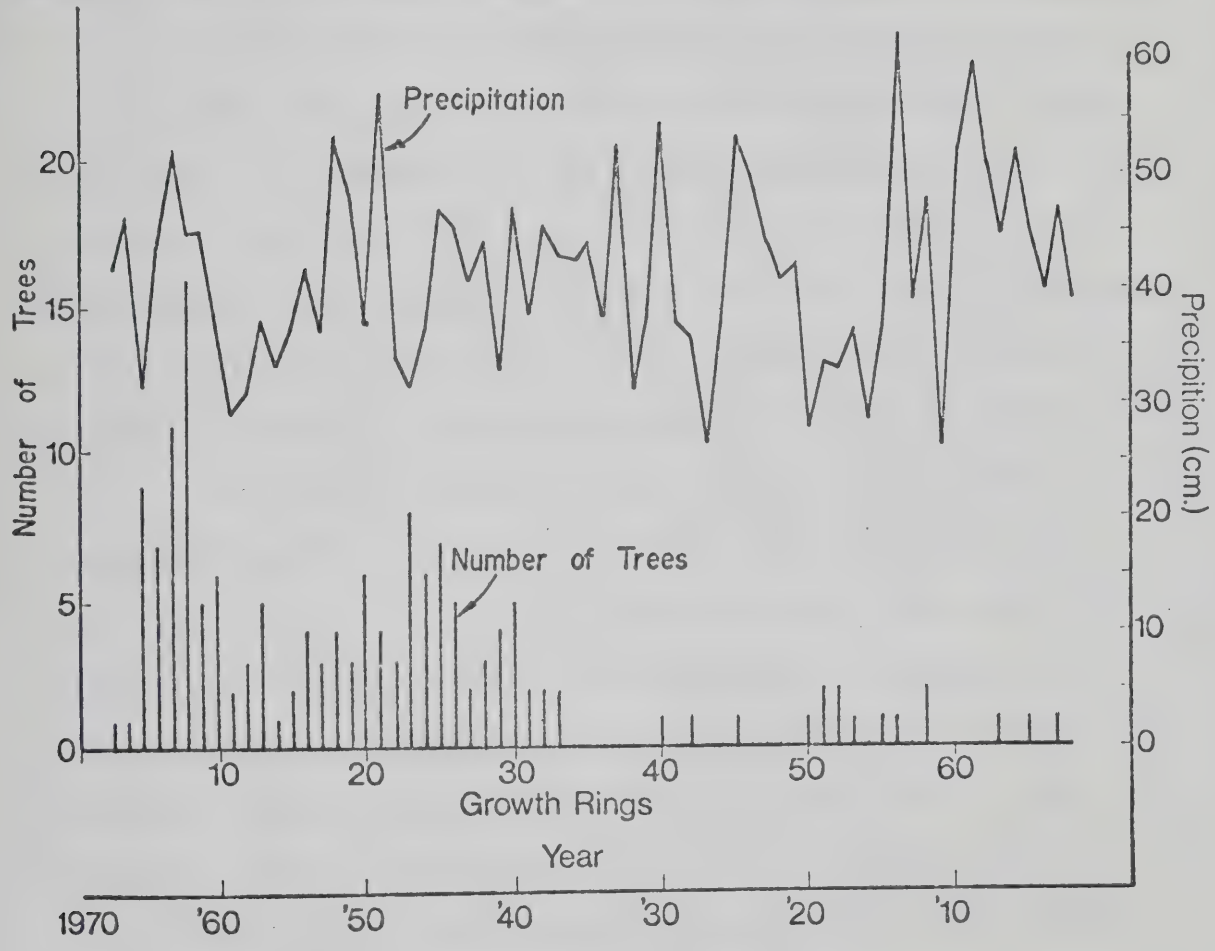


Figure 5. The relationship of growth ring numbers of *Populus tremuloides* to annual precipitation



and that, within the southwestern Alberta Parkland, the rate of conversion of grassy range to trees is about 0.75 percent of the total area per year." They report the general sequence of plant succession to be from grass to willow to aspen to conifer.

The observations indicated that for the area surrounding the study area, the land area covered by *Populus tremuloides* increased from 0.2 percent covered in 1907 to 3.4 percent covered in 1966. This falls within the range of 1.4 to 2.7 feet per year compared to 1.0 to 2.5 feet per year of invasion in Saskatchewan (Maini, 1960). This amounts to 0.05 percent per year compared to the estimate made by Johnston and Smoliak (1968) of 0.75 percent per year in southwestern Alberta.

The results of the soil classification of the *Populus tremuloides* community are presented in Table 10. The pits were dug under mature stands. Two of the profiles are typical grassland soils (profiles two and five). Profile three represents a grassland soil slightly modified by the *Populus* vegetation. Profiles one and four are carbonated regosolic humic gleysols. These are soils usually found in depressions which are usually water saturated for long periods.

The soils of the mature *Populus tremuloides* stands indicate that the trees became established on either black chernozems (grassland soils) or the humic gleysols which occur at the edge of depressions. Although some trees were over 60 years old their average age was 30 years. Evidence of soil modification, reported by Dormaar and Lutwick (1966), was indicated in only one profile. This was the development of an AB horizon in profile three.

Table 10. Soils description and classification of the *Populus tremuloides* community, 1970.

Stand	Classification	Depth cm.	Hor.	Dry Color	Texture
1.	Carbonated Regosolic Humic Gleysol	0-1	L-H		
		1-28	Ah	10YR 2/1	Loam
		28-66	ACk	10YR 5/2	Clay loam
		66	Ccag		
			C Till		
2.	Orthic Black Chernozem	0-1	L-H		
		1-56	Ah	10YR 2/1	Loam
		56-132	Bng	10YR 4/3	Clay loam
		132	Ccag		
			C Till		
3.	Eluviated Black Chernozem	0-1	L-H		
		1-20	Ah	10YR 2/1	Loam
		20-36	AB	10YR 4/2	Clay loam
		36-58	Bt	10YR 3/2	Clay
		58	Cca		
			C Till		
4.	Carbonated Regosolic Humic Gleysol	0-1	L-H		
		1-36	Ahk	10YR 2/1	Loam
		36-74	ACk	10YR 4/2	Clay loam
		74	Ccag		
			C Till		
5.	Orthic Black Chernozem	0-1	L-H		
		1-23	Ah	10YR 2/1	Loam
		23-68	Bm	10YR 5/4	Clay loam
		68	Cca		
			C Till		

d. The *Koeleria cristata - Agropyron smithii* Community

This community was characterized by the high canopy coverage of *Koeleria cristata* and *Agropyron smithii* (Table 11). Stands of this community were more readily recognized as the vegetation occupying what appeared to be eroded pits associated with the solonetz soils. *Koeleria cristata* and *Agropyron smithii* had 59 and 46 percent canopy cover, respectively. Other plants recording more than one percent canopy cover included: *Selaginella densa, Carex eleocharis, Artemisia frigida, Grindelia squarrosa, Antennaria nitida, Achillea millefolium, Poa secunda, Bouteloua gracilis, Deschampsia caespitosa, Hordeum jubatum,* and *Distichlis stricta. Selaginella densa* is a low-growing club moss which forms an understory under the vegetation described. It forms patches of varying sizes.

Stands of this community occupied only 0.5 percent of the study area. The stands were usually located on the lower slopes of many of the knobs but occasionally occurred on level areas in some locations. The plant community was a product of soil conditions caused by the presence of sodium salts in the parent material. The soils were Brown solonetz on the upper slopes and Black solonetz in lower areas. The Ah horizon varied from 2 to 7 cm. in depth over 0 to 3 cm. of Ae horizon. The Bnt horizon was very hard in July 1970. This made it nearly impossible to penetrate with a shovel. Plant roots appeared to penetrate very little into the B horizon as well.

The presence of sodium salts in the soil reduces the availability of water to the plants. The hard pan (Bnt) restricts water movement within the profile. Although annual production was

Table 11. Canopy cover of plant species in the *Koeleria cristata* - *Agropyron smithii* community, 1970. (n = 5)

Species	Canopy Cover (%)
Koeleria cristata	59
Selaginella densa	59
Agropyron smithii	46
Carex eleocharis	35
Poa secunda	15
Grindelia squarrosa	13
Distichlis stricta	8
Artemisia frigida	7
Achillea millefolium	5
Antennaria nitida	4
Bouteloua gracilis	4
Hordeum jubatum	3
Deschampsia caespitosa	2
Stipa spartea var. *curtiseta*	0.8
Erigeron caespitosus	0.5
Cerastium arvense	0.3
Potentilla pensylvanica	0.3
Sphaeralcea coccinea	0.3
Artemisia ludoviciana	0.3
Gutierrezia sarothrae	0.2
Muhlenbergia cuspidata	0.2
Potentilla gracilis	0.2
Chenopodium leptophyllum	0.1

Table 11. Continued.

Species	Canopy Cover (%)
Anemone patens var. *wolfgangiana*	0.1
Potentilla arguta	0.1
Agropyron subsecundum	0.1

not measured, it appeared that the herbage production was considerably less than the arid *Stipa-Artemisia* community.

e. The *Symphoricarpos occidentalis* Community

Stands of this shrub community covered 8.3 percent of the study area. This amounts to 5.39 hectares (13.33 acres) occupied by the community. It formed 124 patches in the grassland, varying in size from 0.004 hectares (0.01 acres) to 0.30 hectares (0.75 acres). The location of the *S. occidentalis* stands was not as predictable as were the other communities investigated. The locations and size of the areas occupied are indicated in Figure 6.

The resulting description of stands of the *Symphoricarpos occidentalis* community is presented in Table 12. These stands were dominated by *Symphoricarpos* (42 percent cover). Other major plant species include: *Festuca scabrella, Stipa spartea* var. *curtiseta, Rosa woodsii, Carex lasiocarpa, C. praticola,* and *C. obtusata*. When comparing these stands to stands of other communities, it may be generally described as a grassland community with a shrub dominant. It should be noted that the understory of the *Populus tremuloides* stands also contained a

Table 12. The mean canopy cover and frequency of the plant species of the *Symphoricarpos occidentalis* community, 1970. (n = 200)

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Carex spp. 1/	50	97
Symphoricarpos occidentalis	42	99
Festuca scabrella	31	76
Stipa spartea var. *curtiseta*	19	54
Rosa woodsii	10	52
Galium boreale	8	51
Artemisia ludoviciana	6	40
Agropyron subsecundum	4	24
Agropyron spp. 2/	2	10
Muhlenbergia cuspidata	2	10
Solidago missouriensis	2	10
Cerastium arvense	1	26
Aster pansus	1	16
Aster laevis	1	14
Achillea millefolium	1	14
Calamogrostis inexpansa	1	7
Potentilla arguta	0.9	9
Danthonia intermedia	0.9	4
Geum triflorum	0.9	4

1/ *Carex* identified in this group include: *C. lasiocarpa*, *C. praticola*, *C. obtusata*.

2/ *Agropyron* identified in this group include: *A. smithii*, *A. riparium* and *A. subsecundum*.

Table 12. Continued.

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Anemone canadensis	0.7	4
Thermopsis rhombifolia	0.6	8
Agrostis scabra	0.5	4
Vicia sparsifolia	0.4	6
Stipa viridula	0.4	3
Juncus balticus	0.4	4
Campanula rotundifolia	0.2	4
Viola nuttallii	0.2	10
Koeleria cristata	0.2	2
Androsace septentrionalis	0.1	0.5
Tragopogon dubious	0.1	0.5
Commandra pallida	0.1	4
Psoralea esculenta	0.1	0.5
Artemisia frigida	0.1	2
Anemone patens	0.1	2
Helictotrichon hookeri	0.1	0.5
Gentianella amarella	0.1	2
Antennaria nitida	-	1
Heuchera richardsonii	-	1
Sisyrichium montanum	-	0.5
Taraxacum officinale	-	2

high cover of *Symphoricarpos occidentalis*. *Symphoricarpos* was a sub-dominant in the *Populus tremuloides* but a dominant in the shrub community.

Table 13 presents the species composition in terms of annual production of the *S. occidentalis* stands sampled. The dominant plant *S. occidentalis* contributes 44.9 percent of the total annual production and 42 percent of the canopy cover. Although the canopy cover of *Festuca scabrella, Stipa spartea* var. *curtiseta, Rosa woodsii* and *Carex* species were 31, 19, 10 and 50 percent, respectively, their annual production was only 21.6, 7.1, 7.1 and 8.4 percent of the total, respectively. This suggests that canopy cover cannot be correlated with weight across all species. This would relate to the canopy characteristics of each species. The grass-like plants contributed 39.2 percent of the total annual production.

There was a high variability among stands. The variation among stands sampled is presented in Appendices 1 and 2. The dominant plant ranged from 26 to 73 percent canopy cover. The annual yield of *S. occidentalis* ranged from 7.19 to 16.26 gms./ 0.1 sq. m. or 719 to 1626 Kg./ha.

Table 14 describes the soils under the *S. occidentalis* community. Two out of the five soil profiles are orthic black chernozems while the remaining three profiles are dark brown chernozems. The depths of soils ranged from 33-94 cms. from the surface.

Table 15 shows the results of the growth ring analysis on the woody stems of *Symphoricarpos*. The majority of the stems had two to nine growth rings, with an average of six. If it is assumed that

Table 13. Species composition in terms of annual production of the *Symphoricarpos occidentalis* community, 1970.

Species	Weight per 0.1 sq. m.	% of Total Herbage	(n = 40)
Grass and Grasslikes			
Festuca scabrella	5.51	21.6	
Carex spp.	2.16	8.4	
Stipa spartea var. *curtiseta*	1.82	7.1	
Poa spp.	0.08	0.3	
Agropyron spp.	0.27	1.1	
Agrostis scabra	0.05	0.2	
Danthonia intermedia	0.02	0.1	
Juncus balticus	0.03	0.1	
Calamagrostis inexpansa	0.11	0.4	
		10.05 gms.	39.3%
Forbs and Shrubs green growth			
Symphoricarpos occidentalis	11.39	44.6	
Campanula rotundifolia	0.06	0.2	
Rosa woodsii	1.80	7.1	
Vicia sparsifolia	0.01	-	
Artemisia ludoviciana	0.74	2.9	
Aster pansus	0.19	0.7	
Galium boreale	0.57	2.2	
Aster laevis	0.26	1.0	
Solidago missouriensis	0.08	0.3	
Achillea millefolium	0.05	0.2	
Thermopsis rhombifolia	0.02	0.1	
Potentilla arguta	0.14	0.5	
Psoralea esculenta	0.06	0.2	
Geum triflorum	0.17	0.7	
		15.54 gms.	60.7%
TOTAL		25.59 gms.	100%
Green		25.59 gms.	32.3%
Wood		18.54	23.4
Litter		35.03	44.3
Total		79.16	100

Table 14. Soil description and classification of the *Symphoricarpos occidentalis* community, 1970.

Stand	Classification	Depth	Hor.	Dry Color	Texture
1	Orthic Dark Brown Chernozem	0-15	Ah	10YR 3/2	Loam
		15-33	Bm	10YR 4/4	Clay loam
		33	Cca		
			C Till		
2	Orthic Dark Brown Chernozem	0-27	Ah	10YR 2/1	Loam
		27-37	Bm	10YR 4/4	Clay loam
		37	Cca		
			C Till		
3	Orthic Black Chernozem	0-29	Ah	10YR 2/1	Loam
		29-66	Bm	10YR 4/3	Loam
		66-89	Btj	10YR 5/4	Clay loam
		89	Cca		
			C Till		
4	Orthic Dark Brown Chernozem	0-10	Ah	10YR 3/1	Loam
		10-25	Bm	10YR 4/3	Clay loam
		46	Cca		
			C Till		
5	Orthic Black Chernozem	0-53	Ah	10YR 2/1	Loam
		53-94	Bm	10YR 3/2	Clay loam
		94	Cca		
			C Till		

growth rings are equal to the age in years this may be interpreted as an average of six years with the majority (96 percent) of the stems falling in the two to nine year age. The maximum age recorded was eleven years.

Using an arbitrary classification of dense, moderate and sparse stands, the mean age was 7.2, 6.3 and 3.3, respectively. Dense was interpreted as *Symphoricarpos* growing to near exclusion of other plant species, sparse as being present but contributing little to the total biomass, and moderate as falling between these extremes. This indicates that as a stand becomes older the density of *Symphoricarpos*, the dominant plant, becomes greater. In view of this it is expected that it may be possible to predict the average age of stands of the community by applying a classification of density to the dominant species.

Table 15. The frequency of the growth rings encountered in the woody stems of *Symphoricarpos occidentalis*, 1970.

Growth Rings	Number of Stems	Percent of Total
1	2	2.2
2	11	12.4
3	10	11.2
4	8	9.0
5	4	4.5
6	10	11.2
7	14	15.7
8	11	12.4
9	13	14.6
10	5	5.6
11	1	1.1
Total	89	100.0

Table 16 gives an indication of the level of sampling in terms of the number of species encountered. There are sixteen species in the community having a mean canopy cover of one percent or more. Thirty plots per stand would have recorded these species. Five plots per stand would have placed the mean canopy cover of the dominant species within 10 percent of the mean of all plots recorded.

Table 16. The level of sampling intensity in terms of plant species encountered in relation to the number of plots for the *Symphoricarpos occidentalis* community.

Plots	Number of Species
5	5-18
10	5-20
20	13-23
30	16-28
40	18-30
80	28-30
120	33
160	37
200	40

f. The *Festuca scabrella* Community

The *Festuca scabrella* community was a major vegetation type of the study area. It covered 50.9 percent of the total area. This amounted to 32.95 hectares (81.41 acres). It occupied a position on the moisture gradient in between the relatively dry *Stipa-Artemisia* and *Stipa-Festuca* communities of the south-facing slopes and the

relatively moist *Carex atherodes*, *Salix petiolaris* and *Populus tremuloides* communities.

This community is described in Table 17 in terms of canopy coverage and in Table 18 in terms of annual herbage yield. The stands of this community characteristically had a high canopy cover of *Festuca scabrella* (84 percent) and the species produced 75 percent of the total annual production. During 1969 the *Festuca scabrella* plants produced a large number of seed heads which grew about one-half meter above the leaves. During 1970, no seed heads could be found. These results agree with the results of Johnston (1967) who observed that *Festuca scabrella* is an erratic seed producer and several years may lapse without a seed set.

It was observed that *F. scabrella* did not follow the description as given by Moss (1959), "densely tufted, often as large tussocks, those enlarging by short rhizomes". The largest tufts did not exceed five cms. in diameter, and the majority were less than one cm. Rhizomes varied in length to a maximum of 16 cms.

The *Festuca scabrella* community was considered species poor, as only ten species had one percent or more canopy cover out of a total of 37 species recorded in the stands. The grasses contributing more than one percent canopy cover were *Stipa spartea* var. *curtiseta* and *Agropyron subsecundum*. The canopy cover of *Carex* spp. ranged from 26.9 to 71.8 percent, with a mean of 49.1 percent. However, the yield of *Carex* spp. was only 9.4 percent of the total yield. The *Carex* spp. were low growing below the canopy of *Festuca scabrella*. Their herbage production was probably reduced because of the high cover of

Table 17. Mean canopy cover and frequency of the *Festuca scabrella* community, 1970. (n = 200)

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Festuca scabrella	84	100
Carex spp. 1/	49	98
Stipa spartea var. *spartea*	20	70
Achillea millefolium	5	50
Rosa arkansana	4	32
Artemisia ludoviciana	3	2
Galium boreale	2	11
Vicia sparsifolia	1	23
Agropyron subsecundum	1	12
Cerastium arvense	1	31
Artemisia frigida	0.9	22
Helictotrichon hookeri	0.7	10
Astragalus flexuosus	0.7	8
Taraxacum officinale	0.6	10
Campanula rotundifolia	0.6	12
Solidago rigida	0.5	8
Anemone patens	0.5	8
Antennaria nitida	0.5	6
Poa spp.	0.4	2
Gentianella amarella	0.3	6
Solidago missouriensis	0.3	6

1/ *Carex* identified in this group included: *C. obtusata*, *C. praticola*, *C. lasiocarpa*.

Table 17. Continued.

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Heuchera richardsonii	0.2	2
Potentilla arguta	0.2	2
Erigeron canadensis	0.2	2
Agrostis scabra	0.2	2
Geum triflorum	0.1	1
Erigeron caespitosus	0.1	2
Viola nuttallii	0.1	10
Erigeron philadelphicus	0.1	4
Astragalus striatus	0.1	3
Koeleria cristata	0.1	0.5
Chrysopsis villosa	0.1	2
Potentilla gracilis	0.1	1
Androsace septentrionalis	-	1
Collomia linearis	-	1
Erysimum cheiranthoides	-	0.5
Cirsium arvense	-	0.5

Table 18. Species composition in terms of annual production of the *Festuca scabrella* community, 1970. (n = 40)

Species	Weight per 0.1 sq. m.	% of Total Herbage		
Grass and Grasslikes				
Festuca scabrella	16.67	74.6		
Stipa spartea var. *curtiseta*	1.73	7.7		
Carex spp.	2.10	9.4		
Agropyron subsecundum	0.06	0.3		
Helictotrichon hookeri	0.10	0.5		
Agrostis scabra	0.01	-		
			20.67 gms.	92.5%
Forbs and Shrubs				
Vicia sparsifolia	0.09	0.4		
Erigeron spp.	0.11	0.5		
Achillea millefolium	0.17	0.8		
Cerastium arvense	0.11	0.5		
Rosa arkansana	0.37	1.7		
Heuchera richardsonii	0.02	0.1		
Artemisia ludoviciana	0.30	1.3		
Artemisia frigida	0.11	0.5		
Galium boreale	0.29	1.3		
Anemone patens	0.03	0.1		
Astragalus spp.	0.05	0.2		
Solidago spp.	0.01	0.1		
Gaillardia aristata	0.01			
			1.67 gms.	7.5%
	TOTAL		22.34 gms.	100%
Green			22.34 gms.	32.7%
Wood			0.12	0.2
Litter			45.78	67.1
Total			68.24	100

Festuca. The forbs and shrubs that contributed more than one percent canopy cover included: *Achillea millefolium, Vicia sparsifolia, Cerastium arvense, Rosa arkansana, Artemisia ludoviciana* and *Galium boreale*. These plants contributed o.4 to 1.7 percent of annual yield. The variation between stands sampled is shown in Appendices 3 and 4.

The average annual yield of the *Festuca scabrella* community was 2067 Kg./ha. of grass and grass-like plants, and 167 Kg./ha. of forbs and shrubs. In terms of grass and grass-like plants, this is twice the yield of the *Symphoricarpos occidentalis* community. In terms of annual yield of forbs and shrubs, the *Festuca scabrella* community yields one-tenth of the *Symphoricarpos occidentalis* community.

Thirty-seven plant species were present in the five stands of this community (Table 19).

Table 19. The level of sampling intensity in terms of plant species encountered in relation to the number of plots for the *Festuca scabrella* community.

Plots	Number of Species
5	7-18
10	11-19
20	15-22
30	21-25
40	22-25
80	30-32
120	35
160	37
200	37

Only five 20x50 cm. plots were required to give ±10 percent of the mean coverage for the dominant species, *Festuca scabrella*. The ten species averaging more than one percent canopy cover always occurred in ten plots.

Table 20 describes the soils sampled in five stands of the *Festuca scabrella* community. The depth of soil ranges from 23 to 50 cms., compared to 33 to 94 cms. in the *Symphoricarpos occidentalis* stands and 58 to 132 cms. in the *Populus tremuloides* stands. The color of the Ah horizon in the *Festuca scabrella* stands ranges from 10YR 3/2 to 4/1 dry color compared to 10YR 3/2 to 2/1 dry color in the *Symphoricarpos occidentalis* stands and to 10YR 2/1 dry color in the *Populus tremuloides* stands. The profiles represent one orthic black chernozem and five orthic dark brown chernozems under the *Festuca scabrella* stands compared to dark brown and black chernozems under the *Symphoricarpos occidentalis* stands, black chernozems under the *Populus tremuloides* stands and rego-humic gleysols under the *Salix petiolaris* stands.

Table 20. Soil description and classification of the *Festuca scabrella* community, 1970.

Stand	Classification	Depth cm.	Hor.	Dry Color	Texture
1	Orthic Black Chernozem	0-15	Ah	10YR 3/2	Loam
		15-38	Bm		Clay loam
		38-44	Cca		
		44	C	Till	
2	Orthic Dark Brown Chernozem	0-20	Ah	10YR 4/1	Silty loam
		20-48	Bm	10YR 5/3	Clay loam
		48-50	Cca		
		50	C	Till	
3	Orthic Dark Brown Chernozem	0-15	Ah	10YR 4/2	Loam
		15-38	Bm	10YR 4/4	Clay loam
		38-42	Cca		
		42	C	Till	
4	Orthic Dark Brown Chernozem	0-18	Ah	10YR 4/2	Loam
		18-46	Bm	10YR 5/3	Clay loam
		46-50	Cca		
		50	C	Till	
5	Orthic Dark Brown Chernozem	0-8	Ah	10YR 4/2	Loam
		8-20	Bm	10YR 5/3	Clay loam
		20-23	Cca		
		23	C	Till	

g. The *Stipa spartea* var. *curtiseta* - *Festuca scabrella* Community.

The *Stipa-Festuca* community covered eleven percent of the study area or 7.12 hectares (17.59 acres) of the 64.75 hectare (160 acre) study area. The 7.12 hectares were made up of 32 stands surrounded by stands of *Festuca scabrella* grassland. The *Stipa-Festuca* stands ranged from 0.04 hectares (0.11 acres) to 0.8 hectares (1.97 acres) in size. These areas occupied the south slopes of knolls ranging from 90 to 270 degrees from true north. The locations of these areas in relation to topography are shown in Figure 6. The canopy cover and frequency of each plant species are listed in Table 21.

The community was dominated by a conspicuous plant, *Stipa spartea* var. *curtiseta* averaging 53 percent cover and 99.5 percent frequency. *Festuca scabrella* was the major subordinate in this community although *Carex* species had a higher canopy cover and frequency. The canopies of both *S. spartea* var. *curtiseta* and *F. scabrella* occurred well above the *Carex* species, limiting their light supply. Furthermore, annual yield of both *Stipa* and *Festuca* was greater than *Carex* (Table 23). The *Artemisia frigida* cover and weight were higher than in the *F. scabrella* community. The *Stipa-Festuca* community was on more arid soils than the surrounding *Festuca* community.

The principal grasslike plants included: *Stipa spartea* var. *curtiseta*, *Festuca scabrella*, *Koeleria cristata*, *Bouteloua gracilis*, *Agropyron smithii*, *Carex eleocharis*, and *C. obtusata*. The principal forbs and shrubs were: *Artemisia frigida*, *A. ludoviciana*, *Anemone patens*, *Antennaria nitida*, *Erigeron caespitosus*, and *Rosa arkansana*.

Table 21. Mean canopy cover and frequency of plant species of the *Stipa-Festuca* community, 1970. (n = 200)

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Stipa spartea var. *curtiseta*	53	100
Carex spp. 1/	37	99
Festuca scabrella	18	74
Agropyron spp. 2/	7	34
Bouteloua gracilis	7	50
Artemisia frigida	4	47
Artemisia ludoviciana	3	22
Koeleria cristata	3	22
Antennaria nitida	3	24
Erigeron caespitosus	3	19
Anemone patens	2	31
Selaginella densa	2	11
Rosa arkansana	2	20
Cerastium arvense	1	18
Erigeron canadensis	1	16
Vicia sparsifolia	0.8	12
Aster pansus	0.7	10
Androsace septentrionalis	0.5	18
Muhlenbergia cuspidata	0.5	7

1/ *Carex* identified in this group include: *C. eleocharis*, *C. obtusata*, *C. heliophila* and *C. scirpoidea*.

2/ *Agropyron smithii*, *A. riparium*, *A. subsecundum* were identified in this group.

Table 21. Continued.

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Phlox hoodii	0.5	2
Lygodesmia juncea	0.4	70
Chrysopsis villosa	0.4	4
Comandra pallida	0.3	6
Thermopsis rhombifolia	0.3	4
Potentilla gracilis	0.2	3
Helictotrichon hookeri	0.2	4
Heuchera richardsonii	0.2	1
Sphaeralcea coccinea	0.2	4
Agrostis scabra	0.1	0.5
Psoralea esculenta	0.1	2
Haplopappus spinulosus	0.1	1
Solidago missouriensus	0.1	0.5
Potentilla pensylvanica	-	2
Potentilla arguta	-	1
Orthocarpus luteus	-	1
Achillea millefolium	-	0.5
Campanula rotundifolia	-	0.5
Solidago rigida	-	0.5
Astragalus striatus	-	0.5
Erysimum cheiranthoides	-	0.5

Annual herbage production for the *Stipa-Festuca* community is given in Table 22. The dominant *Stipa spartea* var. *curtiseta* contributed 50 percent of the grass-like production and 44 percent of the total herbage production. *Carex* species contributed the second highest canopy cover, but only 13 percent of the total annual production. *Festuca scabrella*, the second dominant plant, contributed 22 percent of the total annual production but had only 18 percent canopy cover. *Bouteloua gracilis*, the only short grass present, contributed only 2.4 percent of the total production. *Muhlenbergia cuspidata*, *Koeleria cristata*, and *Helictotrichon hookeri* contributed less than one percent of the annual production. The forbs important in this community contributed only 13.3 percent of the annual production while all forbs averaged only 14.9 percent of the annual herbage production.

In five stands (200 plots) forty plant species occurred (Table 23). Fifteen species out of the forty had a mean cover of one percent or more. This left twenty-five with a cover of less than one percent. Twenty-five plots gave a canopy cover value of about ten percent of the mean cover for the two dominant species. It was observed that ten plots would have recorded all plant species with a cover of one percent or over.

Table 22. Species composition of the *Stipa-Festuca* community in terms of annual production, 1970.

Species	Weight per 0.1 sq. m.	% of Total Herbage	(n = 40)
Grass and Grasslikes			
Stipa spartea var. *curtiseta*	8.44	43.7	
Festuca scabrella	4.14	21.5	
Carex spp.	2.51	13.0	
Agropyron spp.	0.72	3.7	
Bouteloua gracilis	0.47	2.4	
Muhlenbergia cuspidata	0.08	0.4	
Koeleria cristata	0.05	0.3	
Helictotrichon hookeri	0.01	0.1	
		16.42 gms.	85.1%
Forbs and Shrubs			
Erigeron caespitosus	0.77	4.0	
Artemisia ludoviciana	0.42	2.2	
Artemisia frigida	0.27	1.4	
Aster pansus	0.38	2.0	
Rosa woodsii	0.32	1.6	
Anemone patens	0.21	1.1	
Cerastium arvense	0.20	1.0	
		2.57 gms.	13.3%
Vicia sparsifolia	0.04	0.2	
Antennaria nitida	0.13	0.7	
Lygodesmia juncea	0.09	0.5	
Commandra pallida	0.02	0.1	
Potentilla gracilis	0.01		
Orthocarpus luteus	0.01	0.1	
Chrysopsis villosa	0.01		
		0.31 gms.	1.6%
TOTAL		19.30 gms.	100.0%
Green		19.30 gms.	56%
Litter		15.15	44
Total		34.45	100

Table 23. The level of sampling intensity in terms of plant species encountered in relation to the number of plots for the *Stipa-Festuca* community.

Plots	Number of Species
5	7-15
10	9-19
20	14-22
30	16-23
40	21-29
80	33
120	36
160	38
200	40

Table 24 describes the soils found under the five stands of the *Stipa-Festuca* community. All soils were orthic dark brown chernozems and ranged from 30 to 53 cm. to the C horizon.

Table 24. Soil description and classification of five *Stipa-Festuca* stands, 1970.

Stand	Classification	Depth cm.	Hor.	Dry Color	Texture
1	Orthic Dark Brown Chernozem	0-8	Ah	10YR 3/2	Loam
		8-30	Bm	10YR 4/3	Clay loam
		30	Cca		
			C	Till	
2	Orthic Dark Brown Chernozem	0-8	Ah	10YR 3/2	Loam
		8-30	Bm	10YR 5/4	Clay loam
		30	Cca		
			C	Till	
3	Orthic Dark Brown Chernozem	0-10	Ah	10YR 4/2	Loam
		10-36	Bm	10YR 5/4	Clay loam
		36	Cca		
			C	Till	
4	Orthic Dark Brown Chernozem	0-8	Ah	10YR 4/2	Loam
		8-28	Bm	10YR 5/2	Clay loam
		28	Cca		
			C	Till	
5	Orthic Dark Brown Chernozem	0-9	Ah	10YR 4/2	Loam
		9-53	Bm	10YR 4/3	Clay loam
		53	Cca		
			C	Till	

h. The *Stipa spartea* var. *curtiseta* - *Artemisia frigida* Community

This community was identified by two conspicuous codominants: *Stipa spartea* var. *curtiseta* and *Artemisia frigida*. It resembled the *Stipa-Bouteloua* faciation described by Coupland (1950) and the *Stipa-Agropyron* faciation of the Mixed Prairie Association described by Coupland (1961). Canopy coverage and frequency data for this community are given in Table 25. A more detailed coverage by stand is given in Appendix 7.

The community described in Table 25 differs from Coupland's (1950) description of the *Stipa-Agropyron* faciation by its higher cover of *Artemisia frigida* and lower cover of *Bouteloua gracilis* and *Koeleria cristata*. The low cover but frequent presence of *Festuca scabrella* may be explained by the fact that stands of this community occupied small arid islands within the *Festuca scabrella* grassland.

The *Stipa-Artemisia* community covered 2.3 percent or 1.52 hectares (3.75 acres) of the study area. The 1.52 hectare total area was made up of 32 stands ranging in size from 0.008 hectares to 0.16 hectares. Stands of this community occurred on the tops of 32 out of the 35 knobs in the study area.

This community was confined to convex areas having southern exposures and exposed ridges with a southwestern exposure. The location of these stands in relation to topography is shown in Figure 6.

Artemisia frigida had a wide range of canopy cover values varying from 15 to 54 percent cover but its frequency was always high, ranging from 85 to 100 percent (Appendix 7). The other species

Table 25. Mean canopy cover and frequency of plant species in five stands of the *Stipa-Artemisia* community, 1970. (n = 200)

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Carex spp. 1/	38	100
Stipa spartea var. *curtiseta* 2/	37	90
Artemisia frigida	27	96
Agropyron spp. 3/	11	76
Bouteloua gracilis	10	49
Koeleria cristata	8	56
Erigeron caespitosus	8	36
Androsace septentrionalis	3	44
Anemone patens var. *wolfgangiana*	3	28
Festuca scabrella	3	20
Muhlenbergia cuspidata	3	13
Vicia sparsifolia	2	20
Chrysopsis villosa	2	10
Selaginella densa	2	20
Sphaeralcea coccinea	1	14
Antennaria nitida	1	8
Lygodesmia juncea	1	12
Rosa arkansana	1	8
Helictotrichon hookeri	0.7	9

1/ *Carex* species identified in this group include: *C. eleocharis*, *C. obtusata*.

2/ This includes small amounts of *Stipa comata* which was difficult to recognize in the field.

3/ *Agropyron* species identified in this group include: *A. smithii* and *A. riparium*.

Table 25. Continued.

Species	Mean Canopy Cover (%)	Mean Frequency (%)
Potentilla pensylvanica	0.7	7
Cerastium arvense	0.6	8
Phlox hoodii	0.5	10
Orobanche fasciculata	0.4	13
Geum triflorum	0.4	3
Astragalus striatus	0.3	3
Solidago rigida	0.2	2
Agropyron trachycaulum	0.2	2
Astragalus drummondii	0.2	1
Comandra pallida	0.2	4
Calamagrostis montanensis	0.1	4
Erysimum cheiranthoides	0.1	3
Gaura coccinea	0.1	0.5
Achillea millefolium	0.1	0.5
Galium boreale	0.1	0.5
Aster laevis	0.1	2
Artemisia ludoviciana	0.1	0.5
Symphoricarpos occidentalis	0.1	2
Poa interior	-	10
Haplopappus spinulosus	-	0.5
Conringia orientalis	-	0.5
Artemisia campestris	-	0.5
Chenopodium leptophyllum	-	0.1

found in this community gave much smaller ranges. Some low cover species were found in some stands but not in others.

There were 42 species of vascular plants in five stands of this community (Table 26). Eighteen plant species had a mean cover greater than one percent. It was observed that the presence of these species could have been recorded in 30 plots. Twenty-five plots would have placed the canopy cover of the dominant species within a range of ten percent of the mean obtained in 200 plots.

Table 26. The number of plant species encountered with increasing number of plots in the *Stipa-Artemisia* community.

Plots	Number of Species
5	10-11
10	13-17
20	15-20
30	18-24
40	20-28
80	29
120	33
160	37
200	42

A summary of the annual yield per species is given in Table 27. The variation between stands is shown in Appendix 8. The annual yield indicated that grass and grass-like species contributed 52.2 percent of the total annual yield. Forbs and shrubs contributed 47.8 percent of the total annual yield. Although canopy coverage data (Table

25) indicates that *Stipa spartea* var. *curtiseta* is the dominant, and *Artemisia frigida* is the major subordinate, the yield data (Table 27) reveals that *Artemisia* has nearly double the annual production of *Stipa*. In terms of annual yield *Stipa* is clearly subordinate to *Artemisia*. This is due to the inherent difference in the methods used. *Artemisia frigida* weighs much more per unit canopy coverage than do the grasses and most other forbs.

The number of species recorded in herbage production plots was much smaller than for the canopy coverage method because:

i) The sampling intensity was lower.

ii) In some plots some minor species weighed less than 0.05 gm.

The study area was selected because it was assumed that the vegetation had not been markedly influenced by grazing animals in the past. However, analysis of the vegetation compared to Coupland's data of 1950 indicated that the community had been altered. The *Stipa-Artemisia* vegetation on the study area was compared to the hilltop community in a nearby area that had been infrequently mowed for the past 25 years and had not been grazed (Table 28).

In the study area *Erigeron caespitosus, Chrysopsis villosa, Artemisia frigida, Bouteloua gracilis* and *Agropyron* spp. were six, four, three, three, and two times as abundant, respectively, compared to the protected areas. *Festuca scabrella, Rosa arkansana* and *Vicia sparsifolia* were 40%, 70% and 80% less abundant, respectively, in the study area than in the protected area. The difference between areas with respect to *Androsace septentrionalis* was attributed to the fact that it may be considered an increaser under grazing conditions.

Table 27. Annual production of the *Stipa-Artemisia* community by species, 1970 (gm./0.1 sq. m.) (n = 40)

Species	Weight per 0.1 sq. m.	% of Total Herbage		
Grass and Grasslikes				
Stipa spartea var. *curtiseta*	3.39	19.1		
Agropyron spp.	1.16	6.5		
Koeleria cristata	2.40	13.5		
Bouteloua gracilis	0.74	4.2		
Festuca scabrella	0.82	4.6		
Muhlenbergia cuspidata	0.30	1.7		
Helictotrichon hookeri	0.02	0.1		
Poa spp.	0.04	0.2		
			9.28 gm.	52.2%
Forbs and Shrubs				
Artemisia frigida	6.01	33.8		
Geum triflorum	0.20	1.1		
Erigeron caespitosus	0.95	5.3		
Anemone patens var. *wolfgangiana*	0.20	1.1		
Antennaria nitida	0.19	1.1		
Lygodesmia juncea	0.16	0.9		
Rosa woodsii	0.19	1.1		
Androsace septentrionalis	0.04			
Potentilla pensylvanica	0.02			
Orobanche fasiculata	0.09			
Phlox hoodii	0.04			
Sphaeralcea coccinea	0.07			
Cerastium arvense	0.07	3.4		
Comandra pallida	0.01			
Vicia sparsifolia	0.10			
Chrysopsis villosa	0.08			
Erysimum cheiranthoides	0.02			
Symphoricarpos occidentalis	0.01			
Astragalus spp.	0.06			
			8.51 gm.	47.8%
	TOTAL		17.79 gm.	100%
Green			17.79 gm.	64.1%
Litter			9.95	35.9
Total			27.74	100

Table 28. Canopy cover and frequency for the *Stipa-Artemisia* community on the study area compared to a nearby ungrazed area, 1970. (n = 200)

Species	Canopy cover and Frequency	
	Study Area (%)	Protected Area (%)
Carex spp. 1/	38/100	32/99
Stipa spartea var. *curtiseta*	37/90	55/100
Artemisia frigida	27/96	9/78
Agropyron spp. 2/	11/76	4/34
Bouteloua gracilis	10/49	3/39
Erigeron caespitosus	8/36	1/12
Koeleria cristata	8/56	7/56
Androsace septentrionalis	3/44	0.4/8
Festuca scabrella	3/20	6/38
Anemone patens var. *wolfgangiana*	3/28	1/14
Muhlenbergia cuspidata	3/13	3/20
Vicia sparsifolia	2/20	11/28
Selaginella densa	2/20	-
Sphaeralcea coccinea	1/14	0.5/6
Antennaria nitida	1/8	0.2/2
Chrysopsis villosa	1/10	0.4/4
Lygodesmia juncea	1/12	1/16
Rosa arkansana	1/8	4/30
Helictotrichon hookeri	0.7/9	1/11
Potentilla pensylvanica	0.7/7	0.5/6

1/ Includes *C. eleocharis* and *C. obtusata* that were identified.

2/ Identified in this group were: *A. smithii* and *A. riparium*.

Table 28. Continued.

Species	Canopy Cover and Frequency	
	Study Area (%)	Protected Area (%)
Cerastium arvense	0.6/8	- /0.5
Phlox hoodii	0.5/10	0.2/4
Orobanche fasciculata	0.4/13	-
Geum triflorum	0.4/3	0.1/0.5
Astragalus striatus	0.3/3	0.8/4
Astragalus drummondii	0.2/1	0.7/4
Comandra pallida	0.2/4	0.7/16
Agropyron trachycaulum	0.2/3	-
Solidago rigida	0.2/2	0.1/1
Calamagrostis montanensis	0.1/4	0.7/6
Gaura coccinea	0.1/0.5	-
Artemisia ludoviciana	0.1/0.5	0.1/0.5
Symphoricarpos occidentalis	0.1/2	4/12
Achillea millefolium	0.1/0.5	-
Galium boreale	0.1/0.5	-
Aster laevis	0.1/2	-
Chenopodium leptophyllum	- /1	-
Haplopappus spinulosus	- /0.5	-
Poa interior	- /0.5	-
Conringia orientalis	- /0.5	-
Artemisia compestris	- /0.5	- /1
Aster pansus	-	0.6/10
Psoralea esculenta	-	- /0.5

Table 28. Continued.

Species	Canopy Cover and Frequency	
	Study Area (%)	Protected Area (%)
Thermopsis rhombifolia	-	0.4/5
Petalostemon purpureum	-	0.2/1
Oxytropis campestris	-	- /0.5

The species *Erigeron caespitosus, Artemisia frigida, Bouteloua gracilis, Antennaria nitida, Chrysopsis villosa,* and *Agropyron* spp. reacted as increasers under the influence of grazing animals (Johnston et al, 1966). *Festuca scabrella, Rosa arkansana* and *Vicia sparsifolia* were considered decreasers in response to grazing (Johnston et al, 1966). Drought or weather differences may be eliminated as the two areas compared are in close proximity. On the basis of this comparison, grazing animals have altered the relative species composition of the *Stipa-Artemisia* community on the study area. The community in the study area was classed as fair range condition and the protected area was classed as good range condition following Smoliak et al (1969).

A soil description is given in Table 29. The surface horizons were developed from the accumulation and deposition of grasses and forbs. The depth of solum ranged from 5 to 30 cm. This was a thin Ah horizon compared to soils under other communities surrounding these areas. The profiles represent orthic, calcareous and regosolic dark brown chernozems. The shallow calcareous and the regosolic profiles would provide only a limited amount of moisture for the vegetation. Acton (1964) found calcareous dark brown soils on the upper convex portions

of slopes associated with hummocky moraine land forms. The profiles represent part of the catena of the Hughenden Loam described by Bowser et al (1951) for the study area.

The soils of the study area and the nearby protected area were generally the same (shallow dark brown profiles) having low levels of effective moisture. The similar soils and similar topographic position demonstrate the similarity in environment of the *Stipa-Artemisia* stands sampled in the study area and the protected area.

The vegetation and the soils of this community indicated low effective moisture. The presence of plants found in the drier part of the brown soil zone such as *Bouteloua gracilis, Agropyron smithii, Sphaeralcea coccinea, Chenopodium leptophyllum,* and *Haplopappus spinulosus* all indicated aridity and higher prevailing temperatures than in other parts of the study area. The shallow soils calcareous dark brown and regosolic dark brown agree with the plant indicators, demonstrating low effective moisture. Ayyad and Dix (1964) indicated that exposure (south slopes vs. north slopes) was highly significant at higher soil temperatures, thus affecting moisture. Ayyad and Dix (1964) suggested that the moisture regime is a function of both aspect and position, and the heat regime is a product of mainly aspect. The effect of high heat and low soil moisture is indicated by the vegetation and soils of this community.

The canopy coverage of species in an ungrazed, near-climax *Stipa-Artemisia* community was compared with the *Stipa-Festuca* community of the study area (Table 30). The similarity between the two areas was great. Both areas had 27 common species out of a total

of 42 listed in Table 30. With the exception of *Astragalus drummondii*, *Symphoricarpos occidentalis*, *Selaginella densa* and *Erigeron canadensis*, the species not common to both areas had a cover less than one percent.

Table 24 describes the soils of the *Stipa-Festuca* stands. The five pits indicated orthic dark brown chernozems varying in depth from 28 to 53 cms. Table 29 describes the soils of the ungrazed *Stipa-Artemisia* stands. The five pits indicated regosolic and orthic dark brown chernozems varying in depth from 8 to 23 cms. The texture and color of the Ah horizons were approximately the same. The differences between the two areas were reflected in the difference in soil depth and the lack of development of the regosolic profiles. This indicated a slightly more favorable moisture situation in the *Stipa-Festuca* (south slope) stands compared to the *Stipa-Artemisia* (hilltop) stands.

Stipa spartea var. *curtiseta* was virtually the same in both areas. *Festuca scabrella*, although present in both areas, was three times more abundant in the *Stipa-Festuca* community of the south slopes. This variation may be expected as the soils of the south slopes reflected a moister condition than that of the *Stipa-Artemisia* community on the hilltops. This difference was also reflected in the abundance of *Artemisia frigida* and *Koeleria cristata* in the *Stipa-Artemisia* stands. Species such as *Vicia sparsifolia* and *Rosa arkansana* had greater coverage in the *Stipa-Artemisia* stands. *Bouteloua gracilis* had a higher cover in the *Stipa-Festuca* (south slope) stands than in *Stipa-Artemisia* stands.

Table 29. Description and classification of the soils under the *Stipa-Artemisia* community, 1970.

STUDY AREA Stand	Classification	DESCRIPTION Depth cms	Hor.	Dry Color	Texture
1	Thin Orthic Dark Brown Chernozem	0-5	Ah	10YR 5/2	Loam
		5-16	Bm	10YR 7/2	Clay loam
		16	Cca		
			C Till		
2	Regosolic Dark Brown Chernozem	0-11	Ah	10YR 5/2	Loam
		11	Cca		
			C Till		
3	Calcareous Dark Brown Chernozem	0-10	Ah	10YR 4/3	Loam
		10-15	Bmk	10YR 6/2	Clay loam
		15	Cca		
			C Till		
4	Orthic Dark Brown Chernozem	0-8	Ah	10YR 4/2	Loam
		8-23	Bm	10YR 6/2	Clay loam
		23	Cca		
			C Till		
5	Regosolic Dark Brown Chernozem	0-10	Ah	10YR 5/2	Loam
		10	Cca		
			C Till		
Soils of Protected Area for Comparison					
1	Regosolic Dark Brown Chernozem	0-8	Ah	10YR 3/2	Loam
		8	Cca		
			C Till		
2	Regosolic Dark Brown Chernozem	0-8	Ah	10YR 4/2	Loam
		8	Cca		
			C Till		
3	Regosolic Dark Brown Chernozem	0-10	Ah	10YR 4/2	Loam
		10	Cca		
			C Till		
4	Thin Orthic Dark Brown Chernozem	0-8	Ah	10YR 4/2	Loam
		8-18	Bm	10YR 4/2	Clay loam
		18	Cca		
			C Till		
5	Orthic Dark Brown Chernozem	0-11	Ah	10YR 3/2	Loam
		11-20	Bm	10YR 4/2	Clay loam
		20-23	Cca		
		23	C Till		

Table 30. A comparison of the canopy coverage of an ungrazed near-climax *Stipa-Artemisia* community with the *Stipa-Festuca* community, 1970.

Species	% Canopy Coverage *Stipa-Artemisia* Stands	*Stipa-Festuca* Stands
Stipa spartea var. *curtiseta*	55.2	53.0
Carex spp. 1/	32.0	37.1
Vicia sparsifolia	11.0	2.4
Artemisia frigida	9.2	4.1
Astragalus drummondii	8.8	-
Koeleria cristata	7.4	2.6
Festuca scabrella	6.5	17.7
Rosa arkansana	4.5	1.5
Agropyron spp. 2/	4.5	6.4
Symphoricarpos occidentalis	4.3	-
Bouteloua gracilis	3.2	6.6
Muhlenbergia cuspidata	2.7	0.5
Anemone patens	1.4	2.4
Helictotrichon hookeri	1.1	0.2
Lygodesmia juncea	1.0	0.4
Erigeron caespitosus	1.3	3.1
Astragalus striatus	0.8	$\angle$0.1
Calamagrostis montanensis	0.7	-

1/ *Carex* lumps the identified species of both groups being compared.

2/ *Agropyron* lumps the identified species under both groups being compared.

Table 30. Continued.

Species	% Canopy Coverage *Stipa-Artemisia* Stands	% Canopy Coverage *Stipa-Festuca* Stands
Comandra pallida	0.7	0.3
Aster pansus	0.6	0.7
Potentilla pensylvanica	0.5	< 0.1
Sphaeralcea coccinea	0.5	0.2
Chrysopsis villosa	0.4	0.4
Thermopsis rhombifolia	0.4	0.3
Androsace septentrionalis	0.4	0.5
Antennaria nitida	0.2	2.9
Phlox hoodii	0.2	0.5
Solidago rigida	0.1	< 0.1
Erysimum cheiranthoides	0.1	< 0.1
Artemisia ludoviciana	0.1	3.1
Cerastium arvense	-	0.6
Achillea millefolium	-	< 0.1
Selaginella densa	-	1.6
Orthocarpus luteus	-	< 0.1
Potentilla gracilis	-	0.2
Erigeron canadensis	-	1.3
Agrostis scabra	-	0.1
Heuchera richardsonii	-	0.3
Campanula rotundifolia	-	< 0.1
Potentilla arguta	-	< 0.1
Solidago missouriensis	-	0.1
Psoralea esculenta	-	0.1

i. The Distribution of Stands of Plant Communities in the Study Area

The eight plant communities described in the previous sections made up a mosaic of stands differing in life forms, dominant plants and herbage production. The stands of plant communities in the study area were mapped and found to be related to topography. Their spatial distribution is shown in Figure 6.

There was a definite relationship demonstrated between most plant communities and the topography of the study area. The *Carex atherodes* stands occupied the depressions associated with the knob and kettle topography. The *Salix petiolaris* stands tended to form around the *Carex atherodes* stands at a slightly higher elevation. The *Populus tremuloides* stands formed incomplete rings around the *Salix petiolaris* stands at slightly higher elevations. The only community that appeared to have no relation to topography was demonstrated by stands of *Symphoricarpos occidentalis*. The remaining communities were represented by grassland stands of *Stipa-Artemisia, Stipa-Festuca, Festuca scabrella* and *Koeleria-Agropyron*. Stands of *Stipa-Artemisia* occupied the southern exposures of the hill tops. The *Stipa-Festuca* stands occurred on the south-facing slopes. The largest area was represented by *Festuca scabrella* community which in Figure 6 formed the white background areas not occupied by other stands. The *Koeleria-Agropyron* stands occupied small areas on the lower slopes of some hills and small relatively level areas.

An estimate of the herbage production of the study area is presented in Table 31. Values have been estimated as noted to complete the data. The *Carex atherodes* stands occupied 11.1 percent of the total

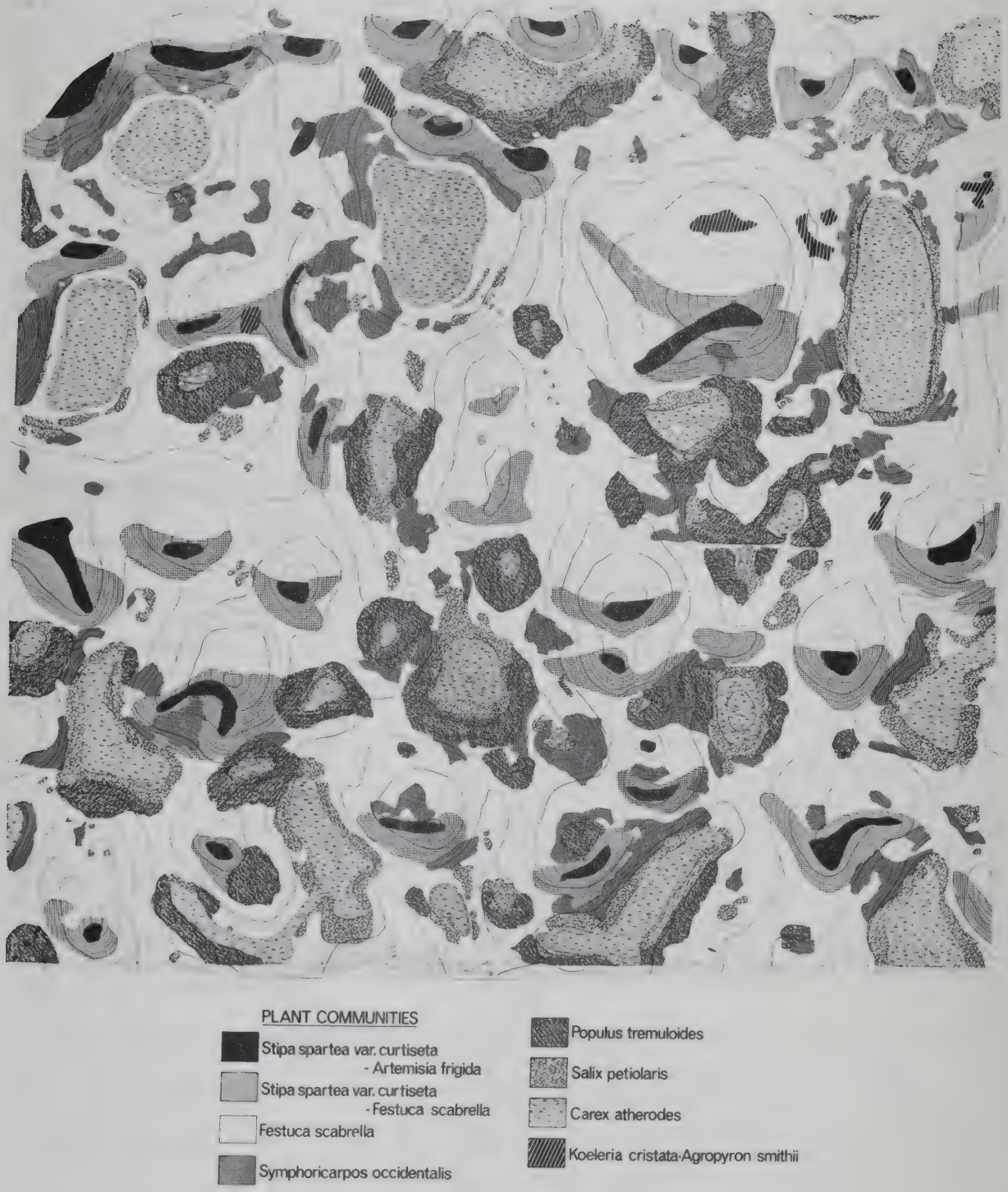


Figure 6. The distribution of stands of plant communities in the 65 hectare study area as overlain on a topographic map. (Scale - 1 cm. = 50 m.) with 60 cm. (2 ft) contour intervals.

Table 31. The proportion of annual herbage yield contributed by each plant community in 1969 and 1970.

1969

Communities	Yield Kg./ha.		Area %	Yield Contribution to Total Area Kg./ha.	% of Total
Carex atherodes	5232		11.1	580	28
Salix petiolaris	528		6.8	36	2
Populus tremuloides	518		9.1	47	2
Symphoricarpos occidentalis	2068		8.3	172	8
Festuca scabrella	2012		50.9	1024	49
Stipa-Festuca	1800	1/	11.0	198	10
Stipa-Artemisia	1164		2.3	27	1
Koeleria-Agropyron	400	1/	0.5	2	0
	Average yield			2076	100

1970

Carex atherodes	500	1/	11.1	56	3
Salix petiolaris	500	1/	6.8	34	2
Populus tremuloides	500	1/	9.1	46	3
Symphoricarpos occidentalis	2559		8.3	212	12
Festuca scabrella	2234		50.9	1137	66
Stipa-Festuca	1930		11.0	212	12
Stipa-Artemisia	1779		2.3	41	2
Koeleria-Agropyron	400	1/	0.5	2	0
	Average yield			1740	100

1/ Estimated, no figures were available.

area and contributed 3 percent (1970) to 28 percent (1969) of the herbage production. The *Salix petiolaris* and *Populus tremuloides* stands occupied 15.9 percent of the area, but contributed only about 5 percent of the total herbage production. The stands of *Koeleria-Agropyron* contributed an insignificant amount to the total production of the area due to their low productivity and infrequent occurrence. The *Stipa-Artemisia* stands contributed only 1 to 2 percent of the total production mainly because of the small area (2.3 percent) they occupied.

The *Festuca scabrella* community was the most important community in that it contributed 49 percent (1969) and 66 percent (1970) of the total herbage production.

The total herbage production for the study area was estimated to be about 2076 Kg./ha. in 1969 and 1740 Kg./ha. in 1970. To relate this production to other areas it may be compared to annual production data collected by the author at the Manyberries substation of the Canada Department of Agriculture, in the mixed prairie of southeastern Alberta; and at the Stavely substation, in the fescue prairie of southwestern Alberta (Table 32).

Table 32. Annual production of three excellent condition grasslands in Alberta during 1969 and 1970.

	Total Annual Yield in Kg./ha.	
Location	1969	1970
Fescue prairie (Stavely)	2721	3766
This study area	2076	1740
Mixed prairie (Manyberries)	844	968

During 1969 the production of the study area was 76 percent of the fescue prairie in southwestern Alberta and 246 percent of the production of the mixed prairie in southeastern Alberta. In 1970 the study area production was 46 percent of the fescue prairie and 180 percent of the production of the mixed prairie.

Production trends in the grasslands in all three locations indicated a more favorable production year in 1970 as opposed to 1969. However, the total annual production was reversed in the study area. This reversal was due to low production in the *Carex* community during 1970, caused by high water levels. The *Carex* stands contributed 580 Kg./ha. or 28 percent toward the total production in a relatively dry season but only 56 Kg./ha. or 3 percent in a relatively moist season. This tended to compensate or level out the normal fluctuation in herbage yields from year to year.

RELEVANCE OF THE STUDY TO RANGE MANAGEMENT

If the assumption was made that plants or plant groups reflect their micro-environment, the number of plant communities identified would indicate a wide range of environmental heterogeneity associated with rolling topography. Level or gently undulating topography would lead to a smaller number of characteristic stands of plant communities. The knob and kettle topography in the study area would lead to a great variety of vegetational types, usually represented by many small stands.

The distribution of stands of each plant community identified was usually quite predictable. The *Stipa-Artemisia* and *Stipa-Festuca* stands nearly always occurred on the south-facing hilltops and upper slopes. This reflected the adaptation of this group of plants to exposed locations. The hilltops and south slopes were some of the driest locations in the study area. These were caused by the more direct angle of solar radiation received during the summer seasons, and the excessive runoff caused by slope and increased velocity of southwesterly winds on the rising southerly slopes of the hills. The area occupied by the *Stipa-Festuca* community will increase as one moves southward and eastward from the study area and decrease as one moves to the moister north and west. This group of plants will tend to occur together where environmental conditions are the same in terms of temperature, moisture and nutrients. These communities will increase at the expense of the area occupied by the *Festuca scabrella* community as one moves south to a regionally dry climate. Actually, the *Stipa-Artemisia* and *Stipa-Festuca* communities reflect islands of mixed prairie within the *Festuca scabrella* grassland.

The *Carex* stands occurred in the dish-like depressions that frequently occur in knob and kettle topography. These areas are recharged each spring with runoff from the surrounding areas. The water levels are high in the spring and are usually reduced or eliminated during the latter part of the season. The plant species in these areas fluctuated widely from year to year and month to month depending primarily on the depth of water. The salinity of these depressions will also cause the species composition to change.

Since the cessation of fires in the early 1900's the area occupied by stands of *Populus tremuloides* has increased. Since this area was apparently used by buffalo primarily for winter grazing (Roe, 1951) fuel would be abundant, facilitating sweeping prairie fires. Frequent prairie fires probably hindered the development of the *Populus tremuloides* community. It has been shown that the stands of *P. tremuloides* have increased in area from 0.2 to 3.4 percent in the space of 60 some years. This invasion appears to have been at the expense of the *Festuca scabrella* plant community. The invasion was not steady but was concentrated into three periods. The spread of *P. tremuloides* led to the reduction of herbage available for grazing animals. The increase in area occupied by *Populus* is mainly attributable to the cessation of prairie fires which were controlled during the settlement era. It would appear that the dominant *P. tremuloides* is close to its ecological limit in the study area. Although no correlation was found directly with invasion and total precipitation, a combination of temperature and precipitation or combinations of moist and dry cycles should be investigated to more fully understand the causes of invasion and recession.

The *Salix petiolaris* stands in the study area were restricted to the moist soils surrounding the *Carex* stands or in draws or depressions within the *Festuca scabrella* community. The *Salix* appeared to occur only on very moist soils but it was limited in its distribution by the depth and duration of standing water. *Salix* is constantly invading into and retreating out of the *Carex* depressions. Evidence of this is the occurrence of a few stems of *Salix* several meters into the *Carex* stands. Many of these small stems died in 1970 when the water levels increased. *Populus tremuloides* usually surrounds the *Salix* areas. This area represents an unstable area of invasion and retreat on the dry edge of the *Salix* stands. The advance and retreat of the *Populus tremuloides* and *Salix petiolaris* communities appeared to be related to the yearly water levels in the depressions. In a series of relatively dry years the *Salix petiolaris* stands advance into the depressions and the *Populus tremuloides* stands advance into the *Salix* community. When the water levels are high during a period of wet years, both *Salix* and *Populus* stands retreat upslope. The net increase or decrease of the *Salix petiolaris* stands over 60 years appeared to be negligible. During a long time period erosion from the slopes will cause filling of depressions, probably allowing *Salix* and then *Populus* to invade these areas.

The *Symphoricarpos occidentalis* stands were the most unpredictable group of plants described. They did not appear to be closely related to soils or to topography. They were found to colonize a wide variety of sites. Although long-term residents stated the area occupied by this community was increasing, the results of this study cannot support or deny this statement. The literature reviewed indicated that this plant

will increase with grazing disturbance. This was not evident on the disturbed hilltop areas.

The herbage production decreases with increased aridity of sites. The south slopes *(Stipa-Festuca)* produce less than the *Festuca* grassland. The herbage production decreases with increase of shrub and tree stratums as they compete for light, water and nutrients. This is evident in the *Salix, Populus,* and *Symphoricarpos* communities. Therefore, changes in tree and shrub communities directly affect the food available to grazing animals.

From a range land point of view the *Carex* community in the depressions is an asset compared to the mixed and fescue prairie of southeastern and southwestern Alberta. Rangelands of the mixed prairie are subject to wide fluctuations in yield, depending on precipitation (Smoliak, 1956). This makes stocking rates unpredictable from year to year. During 1969 and 1970 the production on the study area fluctuated in the opposite direction. The *Carex* stands appeared to compensate for the fluctuations in the grassland. This tended to stabilize the stocking rates between years of high and low precipitation.

The *Festuca scabrella* grassland covered 50.9 percent of the area and during 1969 and 1970 contributed 49 to 65 percent of the herbage production on the study area. Since this area is so important for grazing, management should carefully account for the maintenance of a high production in this plant community.

The *Stipa-Artemisia* community was considered to be a product of deteriorated range and was the only community that was not considered climax. It would have closely resembled the *Stipa-Festuca* in an undisturbed condition. In spite of a light grazing history, stands of

the hilltop community *(Stipa-Artemisia)* were demonstrated to be affected by grazing animals, whereas the other communities reflected little evidence of grazing disturbance. The apparent overuse of the hilltop community suggested that, when offered a choice, animals preferred the *Stipa-Festuca* community and its degraded equivalent, the *Stipa-Artemisia* community. Apparently the cause of the degradation was the preference displayed by cattle for poorer sites, particularly south-facing hilltops. Mott (1955) made the generalization that cattle prefer to graze plant communities in dry as opposed to wet places. Cook et al (1958) indicated that moderate or light stocking may cause a decline in plant vigor on sites where moisture and nutrients are limited (poor sites). He studied areas that had been converted to wheatgrass pastures. His study revealed that poor sites gave utilizations of 80 percent as opposed to 35 percent on the more favorable sites. At the end of three years of grazing more than 70 percent of the plants had been killed on the poor sites, while only 13 percent were killed on favorable sites. If this tendency holds true for the study area then this may be one of the reasons for the deteriorated hilltops. Cook studied a monoculture grazing situation. The study area has different species producing the major portion of the forage on the hilltops and south-slopes as opposed to the favorable sites. The palatability of the dominant plants may be different. The dominant forage produced on the southerly exposures was *Stipa spartea* var. *curtiseta* as opposed to *Festuca scabrella* on the favorable sites. Although both plants are generally considered palatable, a difference in palatability could well be a contributing factor to the preference shown by grazing animals for the southerly

exposures. The *Festuca scabrella* stands consistently had a larger amount of litter from grass produced in previous years than did the *Stipa spartea* var. *curtiseta* dominated stands. Ranchers in the area state that elimination of litter (past year's growth) in ungrazed areas will promote grazing for one or two years.

The deteriorated range condition of the hilltops under many years of very light grazing reveals a serious range management problem. To a range manager, who is striving to maintain a productive range in good condition, this means problems in uneven utilization causing deteriorating range conditions in some areas. Under moderate stocking rates, over a period of time, the net result would amount to poor range condition on the south slopes and excellent range condition on the remainder.

In terms of range management what is the solution? One possible answer would be to allow the south slopes to deteriorate to poor condition to gain effective grazing use of the range unit. The study area would have 13.2 percent of the total area in this category. If 13.2 percent is considered a sacrifice area eventually 13.2 percent of the area would become unproductive and add grazing pressure to other areas. Other possible solutions would be to attempt to change the grazing animals' habits by using rotational grazing systems, changing the type of animal, or changing the season of grazing. Two methods presently used in the area are mowing the forage left after grazing, or winter grazing. It has been observed that grazing animals will shift their grazing to areas that have been mowed and from where the hay has been removed. Winter and fall grazing tends to promote grazing in the *Festuca scabrella*

stands. These management schemes should be studied to determine which will provide the desired results.

Native range such as the study area is rough and rocky and it is doubtful, in the foreseeable future, that this type of land will be converted to cultivated crops. The present sale price of cultivated crops does not justify the cost of cultivating, so these lands must be managed to maintain herbage production. Research is required to develop suggested grazing systems. The increase in area covered by tree and shrub species have a detrimental effect on herbage production. The ecology of these species should be known so their spread may be checked.

SUMMARY AND CONCLUSIONS

Hilly topography causes differences in micro-environments, which in turn offer a wide range of environmental heterogeneity to the plants indigenous to the area. These tend to form distinctive communities in response to the micro-environment created by rough topography.

Seven out of the eight plant communities identified were considered to be near climax vegetation. Stands of these communities differ in terms of species dominance and herbage production. Seven out of the eight plant communities occurred in predictable locations over the study area.

Stands of the *Carex atherodes* community occupied the depressions that collected runoff water from the surrounding area. In 1969, when surface water caused by spring runoff disappeared after a few weeks, heavy herbage yields were realized. In 1970, when deep water remained until late in the season, herbage yields were reduced. The fluctuation in yield appeared opposite to that of other communities.

Stands of *Salix petiolaris* dominated communities occupied the moist soils around the depressions. Although they covered 6.8 percent of the area, herbage production was low.

Stands of *Populus tremuloides* dominated communities occupied some of the most productive soils of the area. Herbage production was considered low. The canopy of the trees caused the lower production. The area occupied by this community has increased significantly in the past sixty years, since the cessation of fire, at the expense of the *Festuca scabrella* grassland and the *Symphoricarpos occidentalis*

shrubland. The invasion was concentrated in three distinct periods but was not correlated with annual precipitation.

Herbage production was reduced by 50 percent in the *Symphoricarpos occidentalis* dominated stands compared to adjoining grasslands. *Symphoricarpos occidentalis* appeared to have a wide ecological amplitude in that it formed a large portion of the understory of the *Populus tremuloides* stands, as well as dominating a variety of other sites throughout the grassland. The dynamics of this community could not be established. The locations of these stands were not as predictable as were stands of other communities.

Stands of the *Koeleria-Agropyron* community occupied too small a portion of the study area on the solonetz soils to be important in planning the grazing management practices.

The stands of *Stipa-Festuca* dominated communities occupied the south-facing slopes of hills. These areas exhibited a lower herbage production than the surrounding *Festuca* community. Grazing animals appeared to prefer the *Stipa-Artemisia* and *Stipa-Festuca* stands over all other communities, as demonstrated by the *Stipa-Artemisia* communities on the tops of south slopes. This creates a range management problem in maintaining a uniformly productive range. To solve this problem consideration should be given to management practices not commonly used in the area.

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Appendix 1. Mean canopy cover and percent frequency of plant species of 5 stands of the *Symphoricarpos occidentalis* community.

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Symphoricarpos occidentalis	26/100	42/100	31/98	37/98	73/100
Festuca scabrella	20/78	12/68	46/100	63/100	14/35
Stipa spartea var. *curtiseta*	36/90	29/78	23/75	5/23	1/5
Rosa woodsii	2/23	13/58	8/75	2/32	23/75
Carex spp. 1/	65/98	53/100	70/100	27/98	33/90
Agropyron spp. 2/	3/15	2/15	4/23	-	-
Agropyron subsecundum	4/35	2/13	4/25	8/48	0.1/2
Artemisia ludoviciana	14/83	12/83	3/30	-	0.1/5
Cerastium arvense	3/60	0.5/8	1/45	0.4/18	-
Aster pansus	4/48	2/25	0.2/8	-	-
Aster laevis	3/32	0.7/13	-	-	2/28
Muhlenbergia cuspidata	6/32	0.4/2	1/10	-	0.1/2
Galium boreale	3/40	19/100	5/32	0.1/2	11/80
Thermopsis rhombifolia	0.8/18	0.4/5	-	2/18	-
Achillea millefolium	1/18	1/10	0.1/5	1/28	1/10
Campanula rotundifolia	0.8/18	-	-	0.1/2	-
Androsace septentrionalis	0.4/2	-	-	-	-
Viola nuttallii	0.1/2	-	0.2/18	0.1/10	0.5/20
Vicia sparsifolia	1/20	0.1/2	0.1/5	0.1/5	0.4/2

1/ *Carex* identified in this group include: *C. lasiocarpa*, *C. praticola*, and *C. obtusata*.

2/ This group includes: *A. smithii*, *A. riparium*, and *A. subsecundum*.

Appendix 1. (Continued).

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Stipa viridula	1/10	0.8/5	-	-	-
Potentilla arguta	0.4/2	4/43	-	-	-
Koeleria cristata	0.4/2	0.8/5	-	-	-
Tragopogon dubius	0.4/2	-	-	-	-
Antennaria nitida	0.1/2	-	0.1/2	-	-
Agrostis scabra	-	0.8/5	0.8/8	-	1/8
Solidago missouriensis	-	6/28	0.5/8	0.1/2	0.6/10
Comandra pallida	-	0.1/2	0.3/15	-	-
Psoralea esculenta	-	0.4/2	-	-	-
Artemisia frigida	-	0.5/8	-	0.1/2	-
Juncus balticus	-	0.1/5	-	-	2/13
Anemone patens	-	0.4/5	0.1/2	0.1/2	-
Danthonia intermedia	-	-	5/25	-	-
Helictotrichon hookeri	-	-	0.4/2	-	-
Heuchera richardsonii	-	-	-	0.1/5	-
Gentianella amarella	-	-	-	0.4/8	-
Geum triflorum	-	-	-	4/20	-
Sisyrinchium montanum	-	-	-	0.1/2	-
Calamogrostis inexpansa	-	-	-	-	7/35
Taraxacum officinale	-	-	-	-	0.2/10
Anemone canadensis	-	-	-	-	3/23

Appendix 2. Species composition of 5 stands by weight (gms/ 1/10 m) in 1970 for the *Symphoricarpos occidentalis* community.

Species	Stands *Symphoricarpos occidentalis* Community					
	1	2	3	4	5	Mean
Symphoricarpos occidentalis	8.28	13.69	11.55	7.19	16.26	11.39
Festuca scabrella	5.21	1.91	6.06	11.48	2.89	5.51
Carex spp. 1/	2.67	4.03	2.04	0.42	1.66	2.16
Stipa spartea var. *curtiseta*	3.03	3.28	2.19	0.58	0.01	1.82
Rosa woodsii	0.16	2.32	0.66	0.12	5.76	1.80
Artemisia ludoviciana	2.51	1.09	0.09	-	-	0.74
Galium boreale	0.22	1.20	0.28	-	1.14	0.57
Poa spp.	0.22	0.04	0.02	-	0.11	0.08
Agropyron spp. 2/	0.66	0.06	0.07	0.59	-	0.27
Cerastium arvense	0.01	-	-	-	-	-
Campanula rotundifolia	0.15	0.02	0.06	0.05	-	0.06
Vicia sparsifolia	0.07	-	-	0.03	-	0.01
Aster pansus	0.56	0.36	0.02	0.01	-	0.19
Aster laevis	1.08	0.04	-	-	0.19	0.26
Solidago missouriensis	0.01	0.22	0.15	0.02	-	0.08
Achillea millefolium	-	0.11	0.01	0.09	0.06	0.05
Thermopsis rhombifolia	-	0.03	-	0.05	-	0.02
Potentilla arguta	-	0.72	-	-	-	0.14

1/ *Carex* identified in this group include: *C. lasiocarpa*, *C. praticola*, and *C. obtusata*.

2/ This group includes: *A. smithii*, *A. riparium*, and *A. subsecundum*.

Appendix 2. (Continued).

Species	Stands *Symphoricarpos occidentalis* Community					
	1	2	3	4	5	Mean
Psoralea esculenta	-	0.29	-	-	-	0.06
Agrostis scabra	-	0.02	0.01	-	0.23	0.05
Danthonia intermedia	-	-	0.09	-	-	0.02
Anemone patens	-	-	0.02	-	-	-
Geum triflorum	-	-	-	0.84	-	0.17
Sisyrinchium montanum	-	-	-	0.02	-	-
Astragalus spp.	-	-	-	0.01	-	-
Juncus balticus	-	-	-	-	0.14	0.03
Viola spp.	-	-	-	-	0,02	-
Taraxacum officinale	-	-	-	-	0.01	-
Calamagrostis inexpansa	-	-	-	-	0.56	0.11
Total Green	24.84	29.43	23.32	21.50	29.04	25.59
Old Wood	6.82	17.19	15.57	6.71	46.42	18.54
Litter	28.84	21.52	40.29	67.72	16,60	35.03
Total	60.50	68.14	79.18	95.93	92.06	79.16
Standard error	±6.8%	±6.2%	±6.4%	±7.8%	±7.7%	±3.6%

Appendix 3. Mean canopy cover and percent frequency of plant species between 5 stands of the *Festuca scabrella* community (1970).

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Festuca scabrella	88/100	85/100	83/100	77/100	86/100
Stipa spartea var. *curtiseta*	18/80	23/62	29/85	24/82	8/42
Achillea millefolium	4/32	9/68	5/55	5/50	4/45
Vicia sparsifolia	2/32	0.5/8	0.6/20	2/28	2/30
Carex spp. 1/	29/100	64/100	72/98	54/100	27/90
Agropyron subsecundum	3/32	0.7/0.2	0.1/2	2/12	1/10
Cerastium arvense	2/50	1/25	0.1/2	2/42	1/35
Artemisia frigida	0.4/23	0.4/15	2/40	1/28	0.1/5
Campanula rotundifolia	0.3/10	0.6/20	0.3/10	1/10	0.5/8
Rosa arkansana	0.5/8	10/55	1/18	0.1/5	6/78
Artemisia ludoviciana	0.2/8	9/48	0.5/8	7/42	0.4/5
Geum triflorum	0.4/5	-	-	-	-
Erigeron caespitosus	0.5/8	-	0.1/2	-	-
Androsace septentrionalis	- /5	-	-	-	-
Erysimum cheiranthoides	0.1/2	-	-	-	-
Solidago rigida	1/15	0.9/10	0.3/10	0.1/2	-
Anemone patens	0.7/12	-	3/60	0.5/10	0.1/5
Heuchera richardsonii	0.1/2	0.4/5	0.1/2	-	0.4/2
Gentianella amarella	0.1/2	0.1/2	0.1/5	0.6/10	0.4/8
Taraxacum officinale	0.4/2	3/38	0.1/2	0.1/5	-

1/ *Carex* identified in this group include: *C. obtusata*, *C. praticola*, *C. lasiocarpa*.

Appendix 3. (Continued).

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Potentilla gracilis	0.4/2	-	-	-	0.1/2
Cirsium arvense	0.1/2	-	-	-	-
Viola nuttallii	-	- /2	0.1/10	0.2/18	0.4/22
Poa spp.	-	2/10	-	0.4/2	-
Erigeron philadelphicus	-	0.5/8	0.1/8	-	0.1/2
Antennaria nitida	-	0.5/8	0.1/2	0.3/10	0.1/2
Potentilla arguta	-	0.4/5	-	-	0.8/8
Erigeron canadensis	-	0.4/5	-	0.4/2	0.4/5
Helictotrichon hookeri	-	0.2/5	2/23	2/18	0.1/2
Astragalus flexuosus	-	3/13	-	0.5/23	0.2/8
Collomia linearis	-	0.1/2	-	0.1/2	-
Agrostis scabra	-	0.1/2	0.4/2	-	0.4/2
Astragalus striatus	-	-	0.6/15	-	-
Galium boreale	-	-	4/25	3/27	2/25
Koeleria cristata	-	-	0.4/2	-	-
Solidago missouriensis	-	-	-	1/20	0.5/10
Chrysopsis villosa	-	-	-	0.3/10	-

Appendix 4. Species composition of 5 stands by weight (gms/ 1/10 m) in 1970 for the *Festuca scabrella* community.

Species	Stands *Festuca scabrella* Community					
	1	2	3	4	5	Mean
Festuca scabrella	14.91	16.16	15.12	19.23	17.94	16.67
Carex spp. _1/	2.17	1.97	3.32	1.82	1.24	2.10
Stipa spartea var.*curtiseta*	2.06	0.78	3.02	2.01	0.79	1.73
Vicia sparsifolia	0.07	0.11	0.01	0.16	0.08	0.09
Achillea millefolium	0.19	0.09	0.29	0.15	0.14	0.17
Agropyron subsecundum	0.07	0.10	0.04	0.08	0.02	0.06
Erigeron caespitosus and *canadensis*	0.16	-	0.28	-	0.11	0.11
Cerastium arvense	0.10	0.12	-	0.15	0.19	0.11
Rosa arkansana	0.02	1.32	0.04	-	0.48	0.37
Heuchera richardsonii	0.06	0.03	-	-	-	0.02
Artemisia ludoviciana	0.01	0.70	0.05	0.76	-	0.30
Artemisia frigida	-	-	0.14	0.42	-	0.11
Taraxacum officinale	-	0.01	-	-	-	-
Galium boreale	-	0.62	0.45	0.25	0.12	0.29
Helictotrichon hookeri	-	0.32	0.09	0.04	0.04	0.10
Erigeron philadephicus	-	0.01	-	-	-	-
Agrostis scabra	-	0.01	0.02	-	-	0.01
Anemone patens	-	-	0.15	0.01	-	0.03

_1/ *Carex* identified in this group includes: *C. obtusata, C. praticola* and *C. lasiocarpa.*

Appendix 4. (Continued).

Species	Stands *Festuca scabrella* Community					
	1	2	3	4	5	Mean
Astragalus spp. 2/	-	-	0.23	0.02	-	0.05
Collomia linearis	-	-	-	0.01	-	-
Solidago spp.	-	-	-	0.02	0.01	0.01
Chrysopsis villosa	-	-	-	0.02	-	-
Gaillardia aristata	-	-	-	-	0.06	0.01
Potentilla arguta	-	-	-	-	0.01	-
Total Green	19.82	22.35	23.25	25.15	21.23	22.34
Litter	39.88	48.59	45.73	43.96	50.62	45.78
Old Wood	-	0.52	-	-	0.09	0.12
Total	59.70	71.46	68.98	69.11	71.94	68.24
Standard error	5.5%	6.4%	5.7%	6.2%	6.4%	2.8%

2/ *Astragalus* identified in this group includes: *A. flexuosus* and *A. striatus*.

Appendix 5. Mean canopy cover and percent frequency of plant species between 5 stands of the *Stipa-Festuca* community (1970).

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Agropyron spp. 1/	23/75	2/15	3/32	6/38	0.9/10
Stipa spartea var. *curtiseta*	44/100	40/98	64/100	59/100	58/100
Carex spp. 2/	67/100	31/100	38/100	32/98	37/98
Festuca scabrella	12/28	28/95	23/100	12/60	13/88
Artemisia ludoviciana	2/20	0.2/5	-	2/2	11/62
Androsace septentrionalis	1/38	0.2/8	0.3/2	0.7/15	0.2/8
Koeleria cristata	4/30	3/35	1/12	3/22	2/12
Bouteloua gracilis	10/65	7/62	4/42	7/40	4/42
Anemone patens	4/32	5/62	2/35	0.4/2	1/22
Antennaria nitida	2/12	1/15	2/30	4/35	6/30
Artemisia frigida	5/45	3/48	4/50	4/38	4/55
Potentilla pensylvanica	0.1/2	-	0.1/5	-	-
Lygodesmia juncea	0.4/5	2/25	-	-	0.1/5
Aster pansus	0.2/5	3/45	-	-	-
Agrostis scabra	0.4/2	-	-	-	-
Selaginella densa	0.1/2	2/12	0.1/2	5/38	-
Potentilla gracilis	0.5/5	-	-	-	0.3/10
Psoralea esculenta	0.2/5	0.2/5	-	0.1/2	-

1/ *Agropyron smithii, A. riparium, A. subsecundum* were identified in this group.

2/ *Carex* identified in this group include: *C. eleocharis, C. obtusata, C. heliophila* and *C. scirpoidea.*

Appendix 5. (Continued).

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Erigeron caespitosus	0.9/10	8/45	0.9/13	-	5/28
Haplopappus spinulosus	0.4/5	-	-	-	-
Vicia sparsifolia	0.8/8	0.1/2	2/28	0.9/20	-
Cerastium arvense	-	1/23	2/5	2/48	1/15
Comandra pallida	-	0.7/15	-	0.2/5	0.6/8
Helictotrichon hookeri	-	0.4/15	0.4/5	-	-
Rosa arkansana	-	0.8/8	2/22	0.6/23	4/10
Muhlenbergia cuspidata	-	0.1/2	-	1/15	1/18
Thermopsis rhombifolia	-	2/15	-	-	0.1/2
Heuchera richardsonii	-	0.4/2	-	-	0.4/2
Campanula rotundifolia	-	0.1/2	-	-	-
Solidago rigida	-	0.1/5	-	-	-
Chrysopsis villosa	-	0.4/2	-	-	2/20
Phlox hoodii	-	0.1/2	-	-	0.8/5
Erigeron canadensis	-	-	0.6/12	3/38	3/30
Sphaeralcea coccinea	-	-	0.8/18	-	-
Potentilla arguta	-	-	0.1/5	-	-
Astragalus striatus	-	-	-	0.1/2	-
Orthocarpus luteus	-	-	-	0.1/5	-
Erysimum cheiranthoides	-	-	-	-	0.1/2
Solidago missouriensis	-	-	-	-	0.4/2

Appendix 6. Species composition of 5 stands by weight (gms/ 1/10 m) in 1970 for the *Stipa-Festuca* community.

Species	Stands *Stipa-Festuca* Community					
	1	2	3	4	5	Mean
Agropyron spp. _1/	2.78	0.08	0.51	0.17	0.05	0.72
Stipa spartea var. *curtiseta*	9.26	10.39	9.25	6.29	7.01	8.44
Festuca scabrella	2.32	3.58	3.57	8.72	2.49	4.14
Carex spp. _2/	2.54	1.50	1.62	5.59	1.29	2.51
Artemisia frigida	0.58	0.11	0.23	0.26	0.16	0.27
Anemone patens	0.20	0.35	0.41	-	0.11	0.21
Artemisia ludoviciana	0.36	-	-	0.20	1.52	0.42
Bouteloua gracilis	1.18	0.22	0.44	0.25	0.28	0.47
Erigeron caespitosus	0.39	0.08	2.42	-	1.12	0.77
Koeleria cristata	0.16	0.02	0.01	0.04	-	0.05
Vicia sparsifolia	0.01	0.02	0.12	0.04	-	0.04
Androsace septentrionalis	0.02	-	-	-	-	-
Antennaria nitida	0.24	0.36	-	0.04	-	0.13
Rosa arkansana	-	0.46	0.14	0.42	0.59	0.32
Comandra pallida	-	0.06	0.04	-	-	0.02
Aster pansus	-	0.48	-	0.62	0.79	0.38
Helictotrichon hookerii	-	0.02	0.03	-	-	0.01
Cerastium arvense	-	0.12	0.68	0.08	0.14	0.20
Sphaeralcea coccinea	-	0.02	-	-	-	-

_1/ The species identified in this group are: *A. smithii*, *A. riparium*, and *A. subsecundum*.

_2/ The species identified in this group are: *C. eleocharis*, *C. obtusata*, *C. heliophila* and *C. scirpoidea*.

Appendix 6. (Continued).

Species	Stands *Stipa-Festuca* Community					
	1	2	3	4	5	Mean
Lygodesmia juncea	-	0.16	0.27	-	-	0.09
Potentilla gracilis	-	-	0.02	-	0.02	0.01
Thermopsis rhombifolia	-	-	0.01	-	-	-
Heuchera richardsonii	-	-	0.01	-	-	-
Muhlenbergia cuspidata	-	-	-	0.12	0.29	0.08
Orthocarpus luteus	-	-	-	0.05	-	0.01
Astragalus spp.	-	-	-	0.01	-	-
Chrysopsis villosa	-	-	-	-	0.04	0.01
Total Green	20.04	18.03	19.60	22.90	15.90	19.30
Litter	12.40	19.88	15.09	9.43	18.98	15.15
Total	32.44	37.91	34.69	32.33	34.88	34.45
Standard error	±7.9%	±5.9%	±6.4%	±10.4%	±6.0%	±3.3%

Appendix 7. Mean canopy cover and percent frequency of plant species between 5 stands of the *Stipa-Artemisia* community (1970).

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Carex spp. 1/	45/100	38/100	27/100	41/100	39/100
Stipa spartea var. *curtiseta* 2/	31/82	44/90	41/92	33/92	37/95
Artemisia frigida	54/100	15/100	28/95	23/98	16/85
Agropyron spp. 3/	3/35	10/88	14/88	16/98	10/75
Bouteloua gracilis	4/32	10/32	10/55	13/60	12/65
Koeleria cristata	11/58	10/78	8/60	6/55	4/32
Erigeron caespitosus	0.8/8	5/30	14/58	13/55	5/30
Androsace septentrionalis	6/58	4/55	0.6/10	1/35	4/62
Anemone patens var. *wolfgangiana*	0.4/5	6/45	4/35	2/35	4/20
Festuca scabrella	1/15	5/25	2/28	4/28	0.5/8
Phlox hoodii	0.3/12	0.1/2	0.6/10	0.9/15	0.4/12
Orobanche fasciculata	1/22	0.1/2	0.6/22	0.3/10	0.1/8
Sphaeralcea coccinea	0.8/8	2/32	0.2/8	2/18	0.1/2
Astragalus striatus	2/15	-	-	-	-
Haplopappus spinulosus	0.1/15	-	-	-	-
Poa interior	0.8/8	0.1/2	-	-	-
Helictotrichon hookeri	2/20	0.2/10	0.1/2	0.9/12	-
Potentilla pensylvanica	2/20	-	0.4/2	0.9/10	0.1/2
Conringia orientalis	0.1/2	-	-	-	-

1/ *Carex* species identified in this group include: *C. eleocharis* and *C. obtusata.*

2/ This includes a small amount of *Stipa comata*, which was difficult to separate from *S. spartea* var. *curtiseta.*

3/ *Agropyron* species identified include: *A. smithii* and *A. riparium.*

Appendix 7. (Continued).

	Stands (% Canopy Cover/% Frequency)				
	1	2	3	4	5
Calamagrostis montanensis	0.2/12	-	0.4/5	0.1/2	-
Solidago rigida	0.1/2	-	-	-	1/8
Erysimum cheiranthoides	0.1/2	-	-	0.1/8	0.1/5
Agropyron trachycaulum	0.4/2	0.6/10	-	-	-
Vicia sparsifolia	0.4/2	0.1/2	3/28	6/70	-
Gaura coccinea	0.4/2	-	-	-	-
Astragalus drummondii	0.9/2	-	-	-	0.1/2
Antennaria nitida	-	0.4/5	-	3/25	2/12
Geum triflorum	-	1/10	-	-	0.4/2
Comandra pallida	-	0.4/12	0.5/8	-	-
Chrysopsis villosa	-	-	2/5	4/15	2/30
Achillea millefolium	-	-	0.4/2	-	-
Galium boreale	-	-	0.4/2	-	-
Selaginella densa	-	-	9/90	0.1/5	0.8/8
Cerastium arvense	-	-	-	3/35	0.1/2
Muhlenbergia cuspidata	-	-	-	0.1/2	17/62
Aster laevis	-	-	-	0.2/5	0.1/2
Chenopodium leptophyllum	-	-	-	0.2/5	-
Artemisia ludoviciana	-	-	-	-	0.4/2
Symphoricarpos occidentalis	-	-	-	-	0.5/8
Artemisia compestris	-	-	-	-	0.1/2
Lygodesmia juncea	-	-	-	-	6/58
Rosa arkansana	-	-	-	-	6/42

Appendix 8. Species composition of 5 stands by weight (gms/ 1/10 m) in 1970 for the *Stipa-Artemisia* community.

Species	Stands *Stipa-Artemisia* Community					
	1	2	3	4	5	Mean
Stipa spartea var. *curtiseta*	3.78	3.61	3.49	3.09	3.00	3.39
Artemisia frigida	12.27	3.94	6.94	3.96	2.94	6.01
Astragalus spp.	0.23	0.02	0.04	-	0.01	0.06
Agropyron spp.	0.76	1.70	1.75	1.32	0.28	1.16
Koeleria cristata	0.46	0.51	0.65	0.26	0.16	0.41
Carex spp.	1.61	2.98	3.18	2.54	1,67	2.40
Helictotrichon hookeri	0.08	-	-	-	-	0.02
Androsace septentrionalis	0.08	0.06	-	0.01	0.04	0.04
Poa spp.	0.11	0.03	-	0.04	-	0.04
Potentilla pensylvanica	0.08	-	-	0.01	0.01	0.02
Erigeron caespitosus	0.51	0.48	1.34	2.02	0.40	0.95
Bouteloua gracilis	0.34	0.36	0.84	0.84	1.32	0.74
Orobanche fasciculata	0.21	-	0.21	0.02	-	0.09
Phlox hoodii	0.17	-	0.04	-	-	0.04
Sphaeralcea coccinea	0.12	0.22	-	0.02	-	0.07
Festuca scabrella	-	2.84	0.85	0.41	-	0.82
Anemone patens var. *wolfgangiana*	-	0.38	0.03	0.43	0.16	0.20
Antennaria nitida	-	0.10	-	0.77	0.10	0.19
Cerastium arvense	-	0.01	-	0.32	-	0.07
Comandra pallida	-	-	0.04	-	-	0.01
Vicia sparsifolia	-	-	0.01	0.47	-	0.10

Appendix 8. (Continued).

Species	Stands *Stipa-Artemisia* Community					
	1	2	3	4	5	Mean
Chrysopsis villosa	-	-	-	0.32	0.09	0.08
Aster laevis	-	-	-	0.01	-	-
Erysimum cheiranthoides	-	-	-	0.08	-	0.02
Muhlenbergia cuspidata	-	-	-	-	1.51	0.30
Lygodesmia juncea	-	-	-	-	0.82	0.16
Solidago rigida	-	-	-	-	0.02	-
Rosa arkansana	-	-	-	-	0.94	0.19
Symphoricarpos occidentalis	-	-	-	-	0.05	0.01
Geum triflorum	-	-	-	-	-	0.20
Total Green Herbage	20.81	18.26	19.41	16.94	13.52	17.79
Litter	14.55	5.20	10.97	9.92	9.11	9.95
Total	35.36	23.47	30.39	26.88	22.62	27.74
Standard error	6.7%	6.0%	6.9%	7.6%	7.8%	3.6%

Appendix 9. Common and botanical names of plant species.

Name	Common Name
**Achillea millefolium*	Yarrow
Agropyron trachycaulum	Slender wheat grass
**Agropyron riparium*	Wheat grass
**Agropyron smithii*	Western wheat grass
Agropyron spicatum	Bluebunch wheat grass
**Agropyron subsecundum*	Bearded wheat grass
Agrostis alba	Red top
**Agrostis scabra*	Hairgrass
**Alopecurus aegualis*	Water foxtail
**Androsace septentrionalis*	Pygmy flower
**Anemone canadensis*	Canada anemone
**Anemone cylindrica*	Long fruited anemone
**Anemone patens L.* var. *wolfgangiana*	Crocus
**Antennaria nitida*	Pussytoes
**Arnica fulgens*	Shinning arnica
**Artemisia campestris*	Plains wormwood
Artemisia frigida	Pasture sage
**Artemisia ludoviciana* var. *gnaphalodes*	Prairie sagewort
**Aster ciliolatus*	Lindleys Aster
**Aster junciformis*	Aster
**Aster laevis* var. *geyeri*	Smooth aster
**Aster pansus*	Tufted white prairie aster
**Astragalus canadensis*	Milk vetch

* Species in Range Management Herbarium, Department of Plant Science, U. of A.

Appendix 9. Continued.

Name	Common Name
Astragalus drummondii	Drummonds milk vetch
**Astragalus flexuousus*	Milk vetch
**Astragalus pectinatus*	Narrow leaved milk vetch
**Astragalus striatus*	Milk vetch
Balsamorhiza sagittata	Balsam root
**Beckmannia syzigachne*	Slough grass
**Bouteloua gracilis*	Blue grama grass
Bromus ciliatus	Fringed brome grass
Calamagrostis montanensis	Plains reed grass
**Calamagrostis inexpansa*	Northern reed grass
**Campanula rotundifolia*	Blue bell
**Carex arthrostachya*	Sedge
**Carex atherodes*	Sedge
**Carex eleocharis*	Sedge
**Carex heliophila*	Sedge
**Carex lasiocarpa*	Sedge
**Carex obtusata*	Sedge
**Carex praticola*	Sedge
Carex rostrata	Sedge
**Carex scirpoidea*	Sedge
**Cerastium arvense*	Chickweed
**Chenopodium leptophyllum*	Goosefoot
Chrysopsis villosa	Golden aster

* Species in Range Management Herbarium, Department of Plant Science, U. of A.

Appendix 9. Continued.

Name	Common Name
Cirsium arvense	Canada thistle
Cirsium vulgare	Bull thistle
Collomia linearis	Collomia
Comandra pallida	Bastard toad flax
Conringia orientalis	Hare's ear-mustard
Danthonia intermedia	Intermediate oat grass
Danthonia parryii	Parry oat grass
Deschampsia caespitosa	Tufted hairgrass
Distichlis stricta	Salt grass
Elaeagnus commatata	Silver-berry
**Erigeron caespitosus*	Fleabane
Erigeron canadensis	Horseweed
**Erigeron glabellus*	Fleabane
**Erigeron philadelphicus*	Fleabane
Erysimum cheiranthoides	Wormseed mustard
Festuca scabrella	Rough fescue
Festuca idahoensis	Idaho fescue
Fragaria virginiana	Strawberry
**Gaillardia aristata*	Gaillardia
**Galium boreale*	Northern bedstraw
**Gaura coccinea*	Scarlet butterfly weed
Geranium bicknellii	Geranium
Geranium viscosissimum	Sticky purple geranium

* Species in Range Management Herbarium, Department of Plant Science, U. of A.

Appendix 9. Continued.

Name	Common Name
Gentianella amarella	Felwort
**Geum triflorum*	Three flowered avens
**Glyceria grandis*	Manna grass
Grindelia squarrosa	Gum weed
**Gutierrezia sarothrae*	Broomweed
**Haplopappus spinulosus*	Spiny iron plant
**Hedysarum alpinum*	Hedysarum
**Helianthus laetrflorus* var. *subrhomboideus*	Sunflower
**Helictotrichon hookeri*	Hooker's oat grass
**Heuchera richardsonii*	Alum root
Hordeum jabatum	Fox tail barley
Juncus balticus	Baltic rush
**Koeleria cristata*	June grass
Lathyrus spp.	Peavine
Lepidium spp.	Peppergrass
**Lygodesmia juncea*	Skeleton weed
Lithospermum ruderale	Stone seed
Mentha arvensis	Wild mint
**Muhlenbergia cuspidata*	Plains muhly
Muhlenbergia squarrosa	Mat muhly
**Orobanche fasciculata*	Cancer root
**Orthocarpus luteus*	Owl clover
Oxytropis campestris	Loco-weed

* Species in Range Management Herbarium, Department of Plant Science, U. of A.

Appendix 9. Continued

Name	Common Name
**Penstemon procerus*	Slender blue beard tongue
**Petalostemon purpureum*	Purple prairie clover
Petasites spp.	Sweet coltsfoot
**Phlox hoodii*	Moss phlox
Picea glauca	White spruce
Plantago major	Plantain
**Poa interior*	Blue grass
Poa palustris	Fowl bluegrass
Poa secunda	Sandberg bluegrass
Polygonum spp.	Knot weed
**Populus tremuloides*	Aspen
**Potentilla arguta*	White cinquefoil
**Potentilla cocinna*	Early cinquefoil
Potentilla fruiticosa	Shrubby cinquefoil
Potentilla gracilis	Graceful cinquefoil
**Potentilla hippiana*	Cinquefoil
**Potentilla pensylvanica*	Pennsylvanian cinquefoil
Psoralea esculenta	Indian bread root
Ribes oxyacanthoides	Wild goose berry
Rosa arkansana	Prairie rose
**Rosa woodsii*	Common wild rose
**Salix petiolaris*	Willow
Scirpus spp.	Bulrush

* Species in Range Management Herbarium, Department of Plant Science, U. of A.

Appendix 9. Continued.

Name	Common Name
Selaginella densa	Clubmoss
**Sesquerella arenosa*	Bladder pod
**Sisyrinchium montanum*	Blue eyed grass
**Sium suave*	Water parsnip
Smilacina stellata	False solomon's seal
**Solidago missouriensis*	Golden rod
**Solidago pruinosa*	Golden rod
Solidago rigida	Golden rod
Sonchus arvensis	Sow thistle
**Sphaeralcea coccinea*	Scarlet mallow
Stachys palustris	Hedge nettle
**Stipa spartea* var. *curtiseta*	Western porcupine grass
Stipa viridula	Green needle grass
Stipa comata	Spear grass
**Symphoricarpos occidentalis*	Western snowberry
Taraxacum officinale	Dandelion
Thalictrum venulosum	Veiny meadow rue
**Thermopsis rhombifolia*	Buffalo bean
Tragopogon dubius	Goat's beard
Typha latifolia	Common cattail
**Vicia sparsifolia*	Vetch
Vicia americana	Wild vetch

*Species in Range Management Herbarium, Department of Plant Science, U. of A.

Appendix 9. Continued.

Name	Common Name
**Viola nuttallii*	Prairie yellow violet
**Zygadenus gramineus*	Death camas

* Species in Range Management Herbarium, Department of Plant Science, U. of A.

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